Rs 5 JULY 1986

science age

INDIAN AERONAUTICS:
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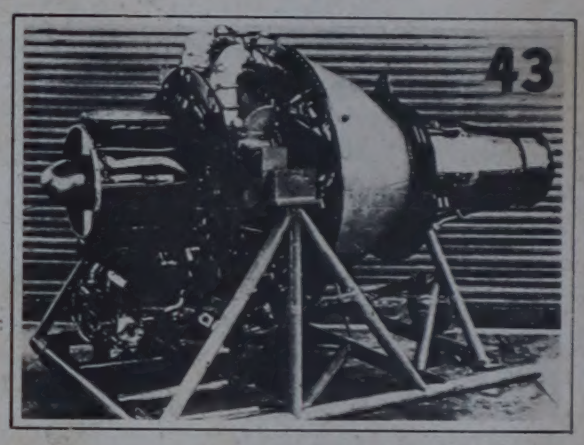

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ADVICE & DISSENT

Science for the people?

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THE JANVANI featuring minster for S & T, Shivaraj Patil, was very dissappointing. The minister, it appeared, was trying to win arguments rather than convince the questioners.

Take, for example, the argument that we are stressing more on technology and less on science. It is false. Actually, we are doing third-rate science and passing it off as technology. Hardly anything is done as technology development in the real sense.

No doubt there are significant achievements in the fields of space, nuclear energy, agriculture, etc. But these are exceptions. A few "star" items really do not bring up the "average" level of technology. Rather than having a few very sharp peaks and low average, one would rather have a "high average" of technology progress with or without peaks.

In India, science itself gets passed off as technology. As a result scientists of doubtful capability but otherwise visible (and clever) have managed to get into key positions of control. Their track record has been uniformly poor; ,they have been taking credit for work done by their junior colleagues. Look at the past 10 years of these eminent scientists in key positions. Have they any real achievements in technology for which they were directly responsible. Is there a single major product system that has been "totally indigenous" right from concept to high level mass production.

These "leaders" have created and maintained such a strong bureaucracy that no significant development in technology is possible. Ask any bright engineering graduate whether he would like to work in government R & D organisation? He'd shrink from that possibility. Why?

Why are we allowing technology import in electronics? Why are we encouraging screw-driver technology? Why has there been no development in computer technology since TDC 316? In fact, we have become more and more dependent on imports. Is this an index of our progress?

There is considerable frustration amongst scientists in most R & D laboratories. Has the government bothered to examine these problems?

There appears to be a group of 5 to 10 people controlling all the science and technology in the country. Whether you want a grant for a project, be considered for a prize or award, nothing will be possible without the blessings of this group.

Why is it that we have no links between university and industry? Is the link not obvious to our planners? Why are universities starved of funds to do any significant technology developments? We spend thousands of crores on imports. Is it not possible to set aside one per cent for real technology development?

Why has there been no significant progress in electronics? Even simple things like radio transcievers which don't need any hi-tech skills are imported? Telephone sets are made by illiterate people in backyards in Hongkong. But we sign technology agreements with multinationals at a fantastic price. Why do we not encourage the local developments of even such simple items? Technology development requires a certain environment and culture. How are we going to encourage this?

Two decades ago we used to get products that were made in India but marked "Made in USA". Now we have products made in Japan over which a crude label, "Made in India", is carelessly slapped on. Is the government policy not encouraging this?

Our import policy is still colonial — higher duties on raw materials and much lower duties on finished products. When will this change? Why does the government still continue with such policies that essentially benefit antisocial elements?

The Department of Electronics has a plan for production of Rs 10,000 crores of goods by 1990. How is this possible without proper infrastructure? A simple calculation will show that such a production will need 1000 engineers from every university for six or seven years. One cannot see this happening. How then will we "achieve" this target? Obviously, by allowing import of kits! In reality, the "kits" are finished products; no one sells kits these days.

Go to any laboratory in the country. There are a lot of museum pieces — most of them are imported (or otherwise) equipment not functioning for want of adequate maintenance support. How will you stop this tremendous national waste? My estimate is, only 15 to 20 per cent of imported equipment is in working condition. The rest is non-functional of which probably a third never worked.

Are there proper linkages between R & D institutions and manufacturing organizations? Why is an organization like BARC concentrating more on university-type of pure research than on applied work that will get directly into production? Is BARC providing the kind of support that the Nuclear Power Board really needs?

We have very competent R & D people in the field of fibre optics. Why then are we going in for total import of fibre optics system and technology? Can not the telecom people support indigenous development?

It is indeed a great pity that while a school boy interested in doing experiments in science is unable to find parts in the market, a businessman can buy an imported car, airconditioners off the shelf! Will the younger generation get any opportunities to develop their talents?

It is very necessary to first appreciate what is very seriously wrong with S & T in the country. Only then will we be able to find a remedy. Of course, if we believe that all is well, then who can help us?

It is obvious that Minister Shivaraj Patil's science advisers are taking him for a ride. He must try to analyze the situation himself, by talking to younger scientists directly (without the older ones being present).

The price of efficiency!

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THE RECENT report that the US Department of Agriculture has decided to slaughter some one milion cows to reduce milk production brings to focus some major aspects dealing with science, productivity and society. It is generally accepted that science and its methods would increase productivity leading to lessening and ultimately removal of poverty.

Indeed science and its methods can greatly increase productivity both in the industrial and agricultural fields and can make life more comfortable. However, any amount of science without a proper social system to take its benefits to all the sections of society in an equitable way will invariably benefit only the rich and affluent.

It is the scientific method that has increased the productivity of the American cow and because of the resultant over-production it faces the butcher's knife in surrender. Many of the advanced countries talk about help given to Third World countries to improve their economic conditions. In fact, it is the rich in the Third World countries who derive

the benefits of such aid. A million cows are going to be slaughtered to keep the price of milk and milk products at a higher level.

Millions of children in the developing countries lose their eye-sight for want of vitamin A (which is abundant in milk and milk products). What could be more useful than diverting the excess milk to the poor and needy?

If we can compare the situation of the cow with an industrial or agricultural worker another aspect of the modern industrial society will come to light. A common worker gives all his life and energy for production. Science and its methods have increased the capacity for man's work and productivity. In the long run, millions of workers will become redundant like the cows and what then would be the policy of the industrialists? The worker has enriched the coffers of many and if the fruits of this work were to be taken only by the elite and the rich he will face a situation similar to the American cow.

Biotechnology: the debate continues

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THIS HAS reference to the letter of Sohan Modak and Dileep Deobagkar and my reply to it, published in SCIENCE AGE of February 1986. In my reply, an important point pertaining to the comments of Modak and Deobagkar on my proposal for R&D-cum-production units has been missed.

My proposal for the establishment of R&D-cum-production units does *not* resemble the concept of technological fix to which they referred. It is fundamentally different. Perhaps, they are not acquainted with the details of the proposal which was made before the National Biotechnology Board (NBTB) was set up. It is, in fact, on the basis of this proposal that NBTB came into existence, although the proposal did not envisage the structure that was given to the NBTB. All this is documented well. The proposal had worked out a detailed plan for a ten-year time frame. The details included the areas of investment, the investment required and the *modus operandi*. In fact, the areas that were mentioned at that time by us are not areas that are now recognized by the NBTB as those in which R&D-cum-production facilities should be set up. Moreover, the initial figure of Rs 20 crores that was given by us for investment in the last five-year plan period was the figure that was accepted by the Science Advisory Council to the Cabinet at the meeting at which NBTB was proposed to be established; it is just that this money was never made available to the NBTB — again because the way it was structured.

In any case, much of the discussion is now only of theoretical value as a separate Department of Biotechnology has now been established by the Government of India. This is what I have been arguing for, right from the time that we first suggested that the country should start a biotechnology programme — which led, as it turned out, to the establishment of the NBTB, presumably because of the special circumstances prevailing at that time.

Tipu's rocket came from Malabar

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R NARASIMHA'S ACCOUNT of Tipu and his rocket regiment (SCIENCE AGE Oct 1985 p 4) tells the history of rockets only partially. The fact is that Mysore got its advanced rocket technology from Malabar.

Both Hyder and Tipu got effective rockets after their raids into northern Malabar which began in 1766. Hyder was an ordinary sepoy mercenary who rose to power in Mysore after the disastrous defeat of the Marathas at Panipat in 1761. Commanding 50 horses and 200 soldiers, Hyder was sent by Nanja raja to help Nasarjung on the death of the Nizam. When Nasarjung was murdered by the Nawab of Cuddappah, his immense treasure of 500 guns and 350 horses fell into Hyder's hands. It became the base of Hyder's power.

With the Marathas helpless after Panipat, he imprisoned the maharaja of Mysore and began to annexe the small Hindu principalities to the west and south of Mysore. By 1763 Hyder took Mangalore and by 1776 Calicut. It was then that he came into contact with rockets. They had long been used in Malabar as a kind of auxiliary weapon and for fireworks.

Even now, nowhere else in India are fireworks and ordinary rockets so well developed as in Kerala. Even the Sivakasi fireworks industry in Tamil Nadu was transplanted from Trichur in Kerala in recent times.

It is quite possible that Malabar got its rockets from China. The Chinese were supreme on the Indian seas in the 13th century. So the Malabari probably learned the art of making gunpowder and rockets from the Chinese. Even now some of the major items of fireworks are known in Malayalam by names like cheena vedi and cheena padakkam, pointing to their Chinese origin.

In ancient Malabar rockets were not only used extensively at festivals but as a weapon too. Marthanda Varma, the maker of modern Travancore, used giant rockets to execute his enemies by tying them to huge rockets and sending them up.

Narasimha is also wrong when he says that the Europeans came to know about rockets from Tipu. As an instrument of war, the freely rising rocket was developed by the Chinese around 1225. Rockets were used in 1258 in Cologne and in 1372 in the Scottish war. Marcus Graecus fully describes rockets about the middle of the 13th century quoting the works of Albertus Magnus and the English "powder monk" Roger Bacon.

The author replies

While rockets were of course known in Europe much before Tipu (as should be clear from the third paragraph of my article), it is widely recognized that these European rockets had no metallic casings and had a performance considerably inferior to Tipu's.

It is also a fact, proved by the existence of Tipu's rockets in the Royal Woolwich Museum in Britain, that the rockets used at that time in India actually had metal cases; as Congreve's work started only two years after Tipu's death, it is certain that it was not Congreve who first provided metallic cases to rockets.

It is not impossible that Hyder learnt something about rockets from his Malabar campaigns, and it would be interesting to find out, more carefully, what this could have been; but certainly (even in Mysore) rockets did not begin with Hyder or his Malabar campaigns. As stated in my article, and as pointed out by D Forrest in *Tiger of Mysore*, Hyder's father already commanded 50 rocketmen.

It is indeed likely that the rocket came to India through the Chinese: the earlier history is briefly covered in my detailed report, but this and some other parts of the report, as well as the supporting references, have been unfortunately left out in the abridgement that appeared in SCIENCE AGE.

The new education policy

THE NATIONAL Policy on Education — 1986 approved by Parliament in May has been widely criticized for being too high on rhetoric. It is not our intention here to react to this policy initiative by the government in a purely critical vein but we cannot resist quoting one passage which epitomizes this aspect particularly well:

"In the Indian way of thinking, a human being is a positive asset and a precious national resource which needs to be cherished, nurtured and developed with tenderness and care, coupled with dynamism. Each individual's growth presents a different range of problems and requirements, at every stage — from the womb to the tomb. The catalytic action of education in this complex and dynamic growth process needs to be planned meticulously and executed with great sensitivity."

Such evocative and emotive passages with little pragmatic content are characteristic of the entire document and leave us troubled and uneasy. For example although we agree with the assertion in the policy document that universalization is the central problem of Indian education and welcome the resolve that "all children who attain the age of 11 years by 1990 will have had five years of schooling, or its equivalent through the non-formal stream. Likewise, by 1995 all children will be provided free and compulsory education up to 14 years of age", we are concerned that the document neither contains any analysis of the factors that have prevented this constitutional guarantee from being fulfilled till today nor does it detail the precise steps by which these objectives would be achieved.

A clearer picture of government thinking in this regard emerges from what its spokesmen say in public. At a recently concluded national seminar on "Electronics for Teaching and Mass Education", both the Minister of State for Science and Technology and the Educational Adviser (Technical) to the Ministry of Human Resources Development argued at great length that the responsibility for the failure of the quest for universalization must be laid squarely at the doors of conventional teaching methods and that success can only be achieved by the use of electronic aids which would at once make the problems of space and time simultaneously more manageable. Even a figure of Rs 50 million for providing computers, colour TVs and VCRs to each of the 55,000 secondary schools in the country was bruited about and it was claimed that the Prime Minister himself had given the blanket assurance that policy implementation in this regard would not be allowed to suffer for lack of funds.

We would like to submit that the lack of any clear enunciation in the document of the socio-political (and allied economic) factors which have stood in the way of universal primary education (like, for example, poverty, the feudal set-up in villages, caste and sex barriers) coupled with the current thrust towards the introduction of electronic aids in schools are indications of an emerging policy which is predicated on the belief that the shortfalls in availability and quality of education, even at the primary school level, can be met by the introduction of electronic aids and more efficient means of long -distance communication, both audio and visual. If this reading is correct, we believe a catastrophe awaits Indian education — a catastrophe even greater than what today passes by that name.

It is our belief that a purely instrument-based approach to universalization is both foolish and retrograde. The reasons for this belief are two-fold. First, an emphasis on and committment to technological aids will effectively mask that lack of political will which has allowed the social and economic obstacles to universalization to remain in place. Second, such an emphasis will accentuate those dehumanizing aspects of our education — its bookishness, its lack of contact with the immediate environment, its irrelevance in relation to our socio-economic problems, — which have made it such an unattractive activity.

We are not trying to argue that electronic aids like TVs and computers have no role to play in education, but rather that they can never be central to the education process; at best they can provide information and enrichment material aimed at exciting the curiosity of the learner. A close analysis of the present educational system would be necessary to define more precisely the limited but legitimate role that technological aids can play in the future. It should indeed be carried out before large portions of our scarce resources are sought to be committed to their implementation.

The drive towards education for all is a very recent one in the world. Even a hundred years ago in England two years of compulsory education was considered adequate. Education was for the few who had, more than ability, the economic wherewithal for pursuing such a luxury. Education meant study of a (often narrow) discipline rather than the development and refinement of the awareness, on the part of the individual, of his natural and socio-political environment which in turn determines his social adjustment — which is what education has now come to mean in the modern context. The result is that the educational system is highly discipline oriented, requiring long and patient (and often frustrating) study of a formal hierarchical structure (sometimes an incomprehensible mathematical formalism) whose immediate application to normal, daily, personal life is rather obscure.

To put it another way, the system seems to be geared towards trying to produce a Nobel Prize winner rather than someone who is scientifically curious about his surroundings. The association of persons from the universities has only helped to accentuate this distortion of the school educational structure. There are many signs of this distortion around us. Jawaharlal Nehru in his autobiography expressed astonishment at an educational system which permitted him to score more in French than a boy who had studied in France and spoke the language fluently.

None of these distortions which have made our education — including primary education — irrelevant and hence unattractive will be rectified by an instrument-based approach. If we wish to tackle the problem of universalization seriously, there are no shortcuts to the massive investments in human (and allied infrastructural) material that are necessary and have long been perceived as necessary.

Our analysis of the problems of universalization is in large measure also applicable to the formal system of education in our country. Here it is possible to be more specific and we believe that the following should be its essential ingredients: (i) curriculum should evolve and not be imposed, (ii) curriculum should be intensive and not extensive, (iii) curriculum development should involve those who are going to do the actual teaching, and (iv) it should include satisfaction of understanding, joy of discovery, struggles of problem

solving, spirit of improvisation. All these should be integrated in such a manner that the level of the curricular material (imparted in a language that the teachers and the taught both feel at home with) should be neither too low (resulting in no challenge) nor too high (leading to frustration and loss of confidence). A good curriculum is not a "destination" in the sense that it is ever reached, but is a "direction" along which one moves continuously.

We believe that the curriculum need not be cluttered with all kinds of information, most of which is not going to be of any use to the child. It will be much better if the child learns during the early school years only a few basic concepts and some elementary language and numeracy skills, and enjoys the learning.

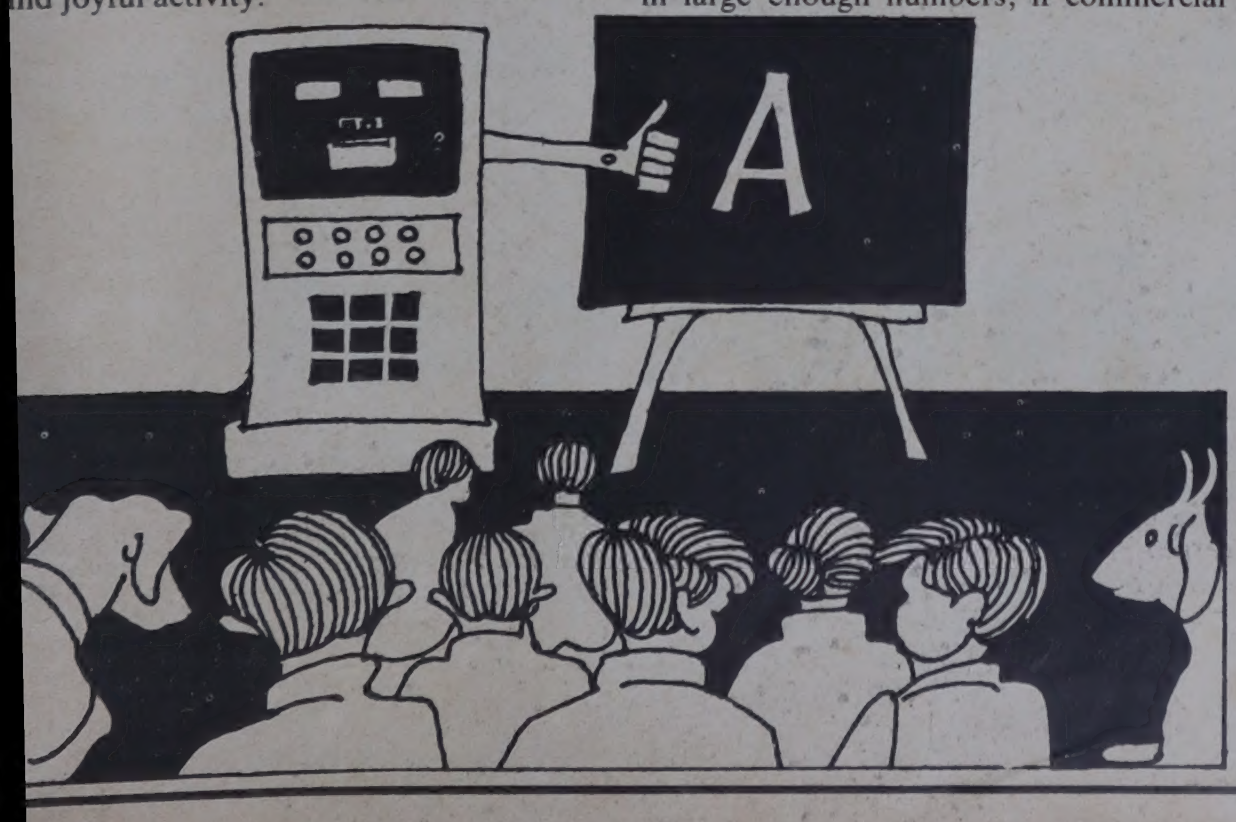
One of the experiments which has shown the feasibility of the ideas expressed above in a cost-effective manner has come to be known as the "Hoshangabad Programme". In this experiment the education of the child is based on his environment. In operational terms it means that the child learns by interacting with objects around him and from things within his own experience. There is considerable emphasis on activity and discussion. The environment of the child becomes his classroom and laboratory and he no longer feels that what he studies bears no relation to his daily life. His sense of isolation and frustration are removed. The child becomes more observant, inquisitive and analytical and his motivation for learning increases. The atmosphere in the classroom becomes lively and learning becomes a participative and joyful activity.

It is obvious that the text-books and curricula for such environment-based education cannot be developed centrally. The responsibility for such work must be vested in "local" agencies. We therefore feel that the decentralization of educational authority should have formed an important part of the new education policy with autonomy being given almost at the district level in the preparation of text and material and the participation of both teachers and students being insured in such an endeavour.

The "Hoshangabad" experiment has, however, at least three limitations. It has been made possible by the efforts of a "lunatic" fringe — a usually youthful group which is prepared to work with little expectation of commensurate returns. If this model is to proliferate, it is imperative that some incentives — financial and otherwise — be devised so that a much larger number of teachers can participate at the national, regional and local levels. The second shortcoming is that the model so far has been effectively limited to the middle school. Unless parallel effort is made at the primary, senior school and the university/college levels, a uniform, discontinuity-free system will not emerge. Finally, it is necessary that the resource material developied is freely available at a nominal price. The last point requires a new approach to production and marketing of educational resource material consisting of books, instruments, apparatus, glassware, chemicals and other material. As long as only academics develop this material, it will be impossible to supply it in large enough numbers; if commercial agencies take over, the profit motive will enter leading to an escalation in costs which may take it beyond the budgets of most schools and colleges. An interesting alternative is a hybrid approach in which the academics do the R & D as part of their regular job, the students do the production on a part-time basis as training and also to earn some money, and a set of professionals do the interfacing and the supervisory job. If the salaries of the professionals can be covered by the government, the overheads will be marginal and the resource material can be distributed almost at cost. This approach, which is most needed in the area of laboratory apparatus, has many advantages like providing practical training to students who do the fabrication, and providing expertie to teachers in development and maintenance of laboratory equipment.

We suggest that work should be immediately initiated in which development of resource material, teacher training and curriculum reforms keep in step with each other. The basic model should be one in which teachers, with student help, are in the forefront and local initiative is encouraged. We feel that, given the political will and a sound policy direction, the educational system can in fact be stirred from its present somnolescent state.

Here we have limited ourselves mainly to two aspects of the New Education Policy. There are many other equally important aspects of the New Education Policy which we have not been able to consider — like the Model or Navodaya schools, women's education, non-formal education — each of which requires careful consideration. The document presents no evidence of a well-thought-out policy on these issues. Only when these are implemented will the full dimensions of the policies be clear for us to offer detailed comments.

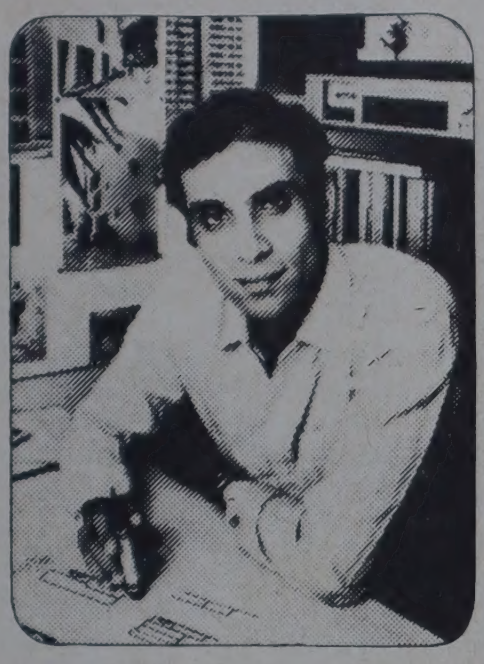


SCIENCE TEACHING GROUP,
DELHI UNIVERSITY

The Science Teaching Group, Delhi University, is an informal association of teachers and students who have been providing academic support to the Hoshangabad Science Teaching Programme for the past twelve years. During this time the programme which incorporates an activity-and enquiry-based approach to teaching science has spread to all the middle schools of Hoshangabad district and to school complexes in about a dozen other districts of Madhya Pradesh.

We have nothing to say.

(Our satisfied customers say it all for us.)



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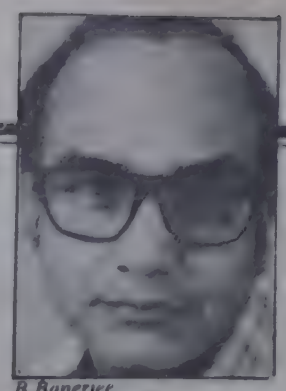
CHERNOBYL AND AFTER



B Banerjee

NUCLEAR POWER has been menacing prospect from its very inception. In the popular imagination, the shadow it has cast has been one of death and destruction. The common man is uneasy about it and in almost all industrially advanced countries vocal minorities oppose it. This fear and mistrust have now once again been raised by the worst nuclear power-plant accident in history in Chernobyl, a small town in Ukraine, 130 km north of Kiev. There are four nuclear reactors in Chernobyl. Reactor number 4 blew up in the early hours of 26 April during a routine maintenance operation. The radioactivity which escaped was borne by winds to many parts of the Soviet Union, Eastern Europe and parts of Scandinavia in Western Europe. It has found its way even to India. The highest level of radioactivity (concentration of radioactive iodine-131) measured in Tarapur (near Bombay), according to BARC, was 7160 milli Becquerel (MBq) per gram (g) on 21 May and 22 May. The highest permitted value is 3000 MBq/g.

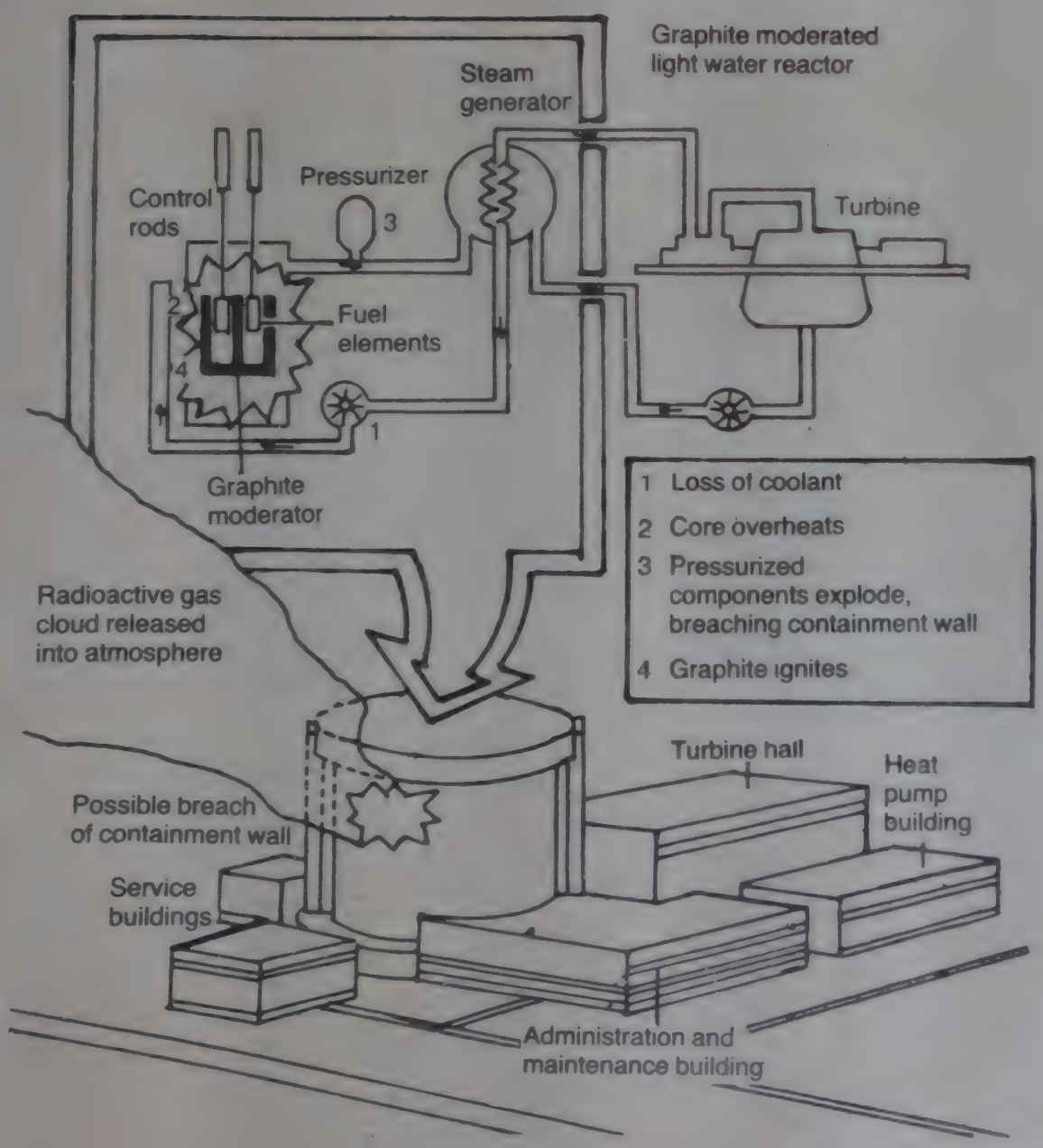
Before we try to understand what could have happened (definitive reports are not yet available) let us look briefly at the way a power reactor (like the one at Chernobyl) works.

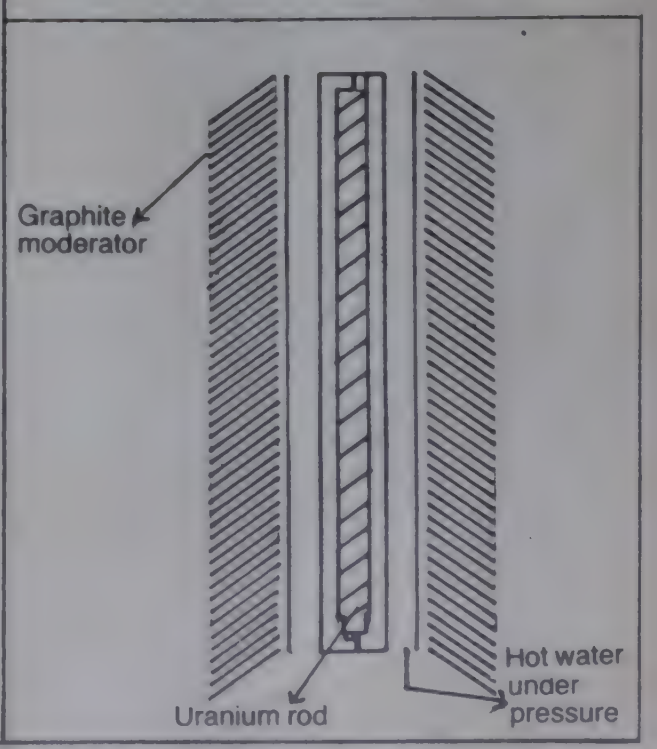
The atomic nucleus comprises two kinds of particles — protons, which are charged, and neutrons, which have no charge. In the atomic nucleus symbol ${}_{z}X^{A}$, X is the chemical symbol of the element, Z is the number of protons and A is the total number of particles, protons and neutrons, in the nucleus. When bombarded with very slowly moving neutrons, the uranium nucleus splits into two nuclei, say, barium ($_{56}$Ba) and krypton ($_{36}$Kr). Along with these two nuclei two or more neutrons are emitted. These can hit further uranium nuclei so that the process can continue uninterrupted, that is a chain reaction can be set up. This is the basic process which goes on in a reactor.

The splitting up of one uranium nucleus releases roughtly 200 MeV (1 million electron volts = 1.6×10^{-6} ergs). About 82 per cent of this energy appears as kinetic energy of the fission products and immediately appears as heat, some of the remaining energy appears as the energy of the emitted neutrons and gamma rays (a penetrating electromagnetic radiation). The remainder is stored in the fission products and is emitted in their radioactive decay process in the form of beta-particles (electrons) and gamma rays. This makes the fission products extremely dangerous. We shall come back to this point later.

In a reactor of the Chernobyl type, the neutrons emitted during the fission process have to be slowed down, otherwise they cannot fission uranium-235 nuclei efficiently and a chain reaction cannot be set up. One of three moderators are used for slowing down neutrons: they are ordinary water, heavy water and carbon in the form of graphite. The Chernobyl reactors have graphite while the power reactors in our country (except Tarapur) use heavy water as moderator. The uranium (actually, uranium oxide) is made into rods and canned in containers made of an alloy of zirconium metal (zircalloy). The heat gen-

What happened at Chernobyl





Aftermath at Chernobyl, as seen on Soviet television. On the right is a portion of building destroyed in the mishap

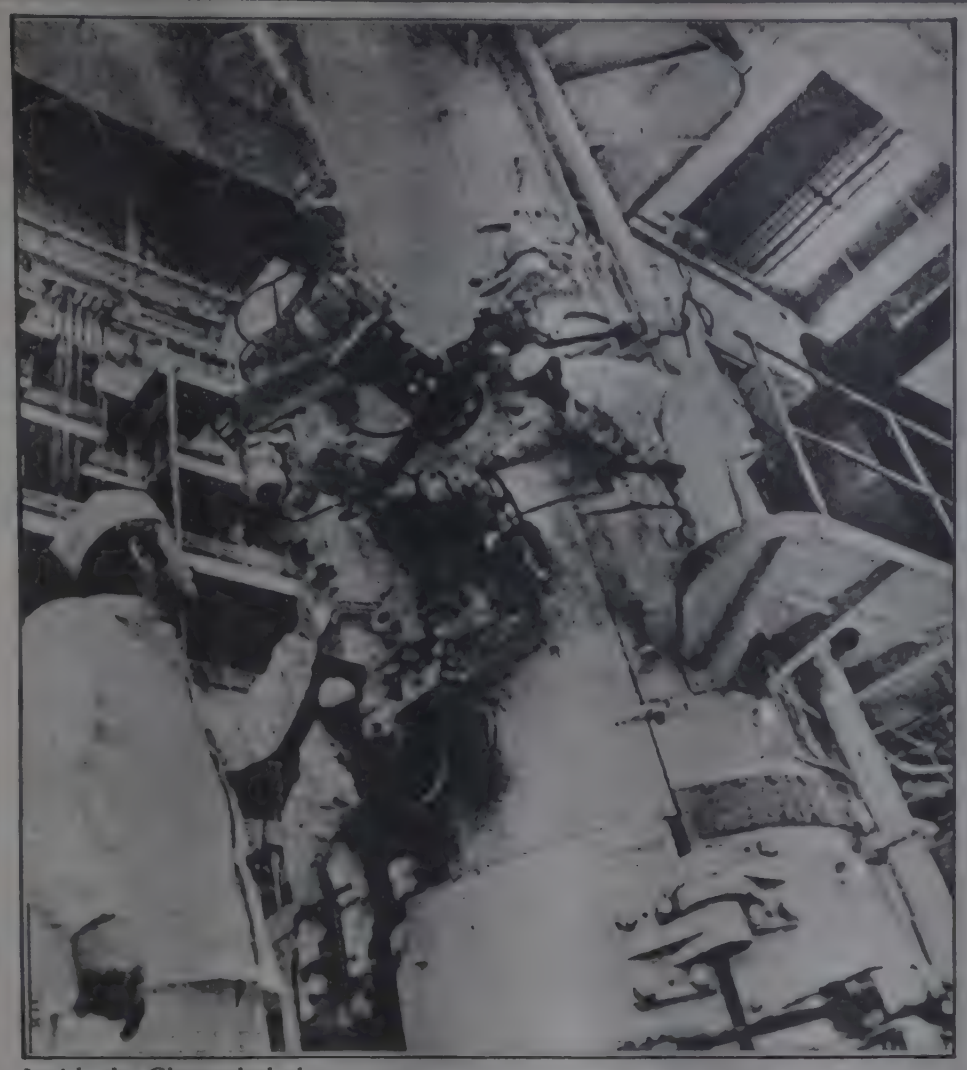
erated in the reactor is removed by passing hot water at 270°C under pressure through zircalloy pipes which surround the uranium fuel rods (see Fig). Boiling water and steam come out of the reactor. The steam is separated from the water and used to drive turbines for producing electricity.

Now what happened at Chernobyl? The Soviets have given us the barest of facts. On 26 April, during a routine maintenance schedule, when the reactor was operating at only 5-7 per cent of its full power of 1000 million watts (MW) there was a sudden surge of power. The roof of the concrete housing of the reactor, designed to withstand a pressure of 4.5 atmospheres (twice the pressure in a car tyre), was blown off and two people were killed. The explosion damaged the reactor, and the zircalloy cans containing the uranium fuel rods were ruptured, releasing volatile radioactive iodine ($_{53}I^{131}$) and cesium ($_{55}Cs^{137}$) in the air. The graphite moderator surrounding the reactor core was hot enough to ignite spontaneously as soon as it was exposed to air. The fire raged for nearly a week. Tons of sand, lead, clay and boron were dropped from air to extinguish the fire and to contain the radioactivity. However, one serious danger remained.

The fuel, even when the fission of uranium nuclei has stopped, has its own source of heat — the residual radioactivity which generates about seven per cent of the heat produced during full power operation of the reactor. Being buried under sand, the reactor could not cool down and some uranium rods may have melted. The molten core would then have begun to bore its way into the floor. The main danger came from the pool of water placed in a concrete box under the reactor for washing out radioactive material from gases leaking through the floor. If the molten core had reached the water by melting the concrete, a steam explosion would have resulted spewing more radioactivity in the surroundings. The ultimate disaster of the molten core going through the foundations of the reactor building and reaching the soil and underground water (called "China Syndrome" after the title of a film in which something similar happens) was averted by Soviet rescue workers who were able to empty the pool and pump in concrete to strengthen the whole structure.

In a reactor accident, the greatest danger for humans is the release of radioactive elements from the core into the surroundings and the atmosphere. Chernobyl is not the first accident where this has happened. There have been two major accidents, one at Windscale, England (1957) and the other at Three Mile Island, USA (1979). At Windscale, radioactive material was carried by air and deposited over England, Wales and parts of northern Europe. The major radioac-

Satellite image of Chernobyl. The arrow points to reactor, at one end of the large cooling pond.



Inside the Chernobyl plant

tive nucleus found on the ground was iodine-131 ($_{53}I^{131}$) which is easily absorbed in the human body and cells are damaged by the electrons emitted by it. In the Three Mile Island accident the release of iodine-131 was small. In Chernobyl, according to the International Atomic Energy Agency, about half the radioactive material released was iodine-131. However, the level of radiation was surprisingly low (10-15 millirems per hour within a 30 km zone). One plausible explanation is that the radioactive plume coming out of the reactor was so hot that it rose very high in the air, sparing the immediate neighbouring areas from a heavy dose of radiation. So far 17 deaths have been reported and 299 are being treated in Moscow, mainly for severe exposure to gamma rays. Robert Gale, an American expert who was invited by the Soviet Government to treat the radiation victims, has said that nearly 100,000 people evacuated from the Chernobyl areas will need to be examined annually for many years for symptoms of radiation exposure. The typical symptoms are depression of blood-cell formation, liver toxicity and gastro-intestinal disorders.

It will be a long time before we know, if at all, what exactly went wrong in reactor number 4. Right now, we can only speculate. Boris Sceherbina, chief of the accident investigators, said that probably one of the pipes carrying pressurized water cracked, resulting in a mixture of steam and water getting into the graphite blocks. Hydrogren is produced when water reacts with hot graphite. This hydrogen somehow mixed with air and exploded, damaging the reactor building and allowing air to come into contact with the heated graphite which, as a result, caught fire. The temperature would have risen sufficiently causing a partial meltdown of the fuel rods. The general impression outside the USSR is — and the Soviets have not denied it — that the reactor did not have any secondary containment building to hold the hot gases released from the main reactor building. It also did not have a pressure suppression system which can reduce the effects of any excessive energy release.

More important than the causes of this terrifying accident are the lessons we can draw from it. What are they? First, the devotees of nuclear power should grasp a simple truth — that it is an extremely risky enterprise. Every technology takes time to become reliable. It took nearly a hundred years to make the railways a safe means of transport. The chemical industry has taken even longer. Air travel has become safe after sixty years of continuous improvement. There are always ghastly failures. Bhopal and Challenger are tragic reminders of that.

Unfortunately, nuclear power is different. A reactor accident not only kills people at the time but endangers the health of generations to follow. The impact of the accident is so huge that it is not possible to demand from people that they bear the cost of learning from mistakes. The reactors in India are perhaps safer than the Chernobyl ones. Because they have heavy water as the moderator and, as the chairman of the Nuclear Power Board assured us, they have secondary containment systems. Even then it would be absurd to claim what happened in Chernobyl cannot happen here. Precisely because machines fail in a way in which the designers did not anticipate. It is therefore important to know if our reactors are prepared for any emergency. Do we have contingency plans for worst case scenarios? It took the Soviet Union nearly two days to inform the world about the accident — that too after Sweden had done so and after American satellites were photographing the fire. The 40,000 residents of the town of Chernobyl, only 15 km from the reactor, were evacuated a full six days after the accident. Are our communication and evacuation plans any better?

Second, nuclear power authorities — not only in the Soviet Union — tend to be secretive. They habitually hide the risks and dangers of nuclear power from us. This is grievously wrong. No group has the right to arrogate to itself the power to suppress facts which concern the present and future well-being of the very people they are supposed to be working for. After Chernobyl, the Ministry of Environment in Britain has decided to make news of all reactor accidents, minor or major, public. This is a good example to follow for nuclear power authorities everywhere.

Lastly, the desirability of nuclear power is again in question. Should we be prepared to pay such a high price just because there is no other alternative (at the moment) after our fossil fuels are exhausted? In the aftermath of Chernobyl different countries are answering the question differently. The West German Social Democratic Party has announced that it will scrap nuclear power stations if it wins the next election. Italy and Holland have stopped all further constructions. In the United States no new power stations have been ordered for many years. The future of the existing ones are in jeopardy. Only Britain and France seem to be strongly committed to nuclear power.

It seems to me nuclear power cannot be abandoned totally, at least till an alternative is found. In the meantime nuclear power authorities, here as well as elsewhere would be well-advised to scrutinize their design plans and allow for far greater safety margins. After all, only two months ago, the US edition of the magazine *Soviet Life* published a nine-page feature on Chernobyl with the headline "Total Safety" and dismissed any idea of a meltdown as "incredible"!

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WHAT'S WRONG WITH OUR PRIVATE SECTOR?

H K Paranjape

ONE HEARS quite a bit about the inadequacies and inefficiencies of the public sector. Much less is heard about the private sector except when, in contrast with the public sector, some examples are given or assumptions made about its efficiency and praiseworthy role.

My contention is that there is something very wrong with our private sector.

It goes without saying that it was private sector industry and business which, against very heavy odds, made a dent in the stagnation in the Indian economy which had persisted for quite some time as a result of British rule. A useful combination of circumstances certainly helped, as in the case of the cotton textile industry in Bombay in the '70s and '80s of the 19th century. But it cannot be overlooked that it requires a very special combination of business acumen, economic foresight and national pride which made a person like Jamshedji Tata think of developments like the steel plant at Sakchi, hydro-electrical power stations in the Western ghats, and a scientific research establishment at Bangalore. Such developments had to be carried out against not only the indifference, but almost active opposition, of the foreign rulers.

The Swadeshi movement which began in the beginning of the 20th century as a part of the nationalist movement helped Indian industry to obtain a foothold in the Indian market even before some protection by way of tariffs was provided by the government in the inter-war period. At the same time, it also provided a useful climate in which patriotic businessmen could show the courage and the ambition to think of the potentialities of the future Indian economy. It was thus that, even before Independence, some industrial transformation had already taken place in the country and a certain basis of industrial knowledge, business experience and modern commercial organisation had already come into existence. The cutting off of supplies from traditional suppliers of industrial goods in overseas areas during the Second World War period provided a further boost to this development.

At the same time, some of the peculiarities of the Indian private sector began to be clear even in this pre-Independence period. The managing agency system, which developed initially to meet the special requirements of British agency houses, was adopted by Indian business families to establish their control over an increasing number of industrial and business units. Another pecularity was that, almost from the beginning, the control of industrial ventures was in the hands of persons who grew up in the business of trading and financing, and who had little knowledge about or experience of the technology of manufacturing. In fact, the Indian industrial ventures had as its technical experts employees, who were either foreigners or Indians but who had little to do with the control and management of the ventures in which they worked. The almost total neglect of R & D, or of attempts at industrial innovations related to Indian circumstances, resources and factor endowments, was a natural outcome of this peculiarity. In fact, except for a few minds with great foresight like Jamshedji Tata's, the importance of science and technology for industrial development was not very much appreciated by those who started industrial ventures in the country.

The period of the Second World War not only provided an opportunity for Indian industry to develop and thrive as a result of the cutting off of supplies from the traditional industrial suppliers in the West, but also provided considerable opportunities for profiteering. With inflationary finance resulting in price escalation, black marketing became rampant and, with Government's attempts to impose heavy taxation on higher incomes and excess profits, tax evasion also began to thrive on a large scale. We can trace the beginnings of the parallel economy in India essentially to this period. Of course, at that time, tax evasion was also considered to be a sign of patriotism as the Government continued to be controlled from Whitehall!

After Independence,even though there was some apprehension in the minds of the business community, especially at the time of formulating the Second Five Year Plan, what with the adoption of the "socialist pattern of society" as the objective of economic policy, the nationalization of the Imperial Bank and the business of life insurance, and the special importance given to the public sector in major developments in steel, engineering and machine building, the Industrial Policy Resolution of 1956 reiterated the approach that the private sector need have no apprehensions about its future role; and that Government would continue to give encouragement and assistance to it in its further development.

It was obvious to all those who were involved in the task of improving the Indian economy after Independence that a major shortcoming of this economy as it worked under the British was its over-dependence on imports for almost all basic requirements of economic growth. A major change since 1947 in the situation has been that the country has become far less dependent on foreign sources for such essential requirements. There has been significant development of mining, metallurgy, machine building and basic chemicals. To what extent has the private sector contributed to this development?

It may be said that the government policy has reserved a considerable part of this basic area to the public sector; and the government has not usually permitted the private sector much scope. But it should not be overlooked that, even when there was no such constraint, there was no realization of the necessity to develop some of these areas. When the proposal for establishing a public sector steel plant at Rourkela was mooted in the early '50s, and it was later suggested that it should have a capacity of one million tonnes, a prominent industrialist in the private sector had raised the question whether the country needed so much steel! But for the initiative taken by the planners and policy makers in the public sector, much of the development of the basic industries in areas like steel, machine tools, heavy machine building etc. would not have taken place.

In fact, while the public sector is quite frequently, and to some extent rightly, criticized for the lack of attention by its leaders to profit making, the private sector in the country can almost be accused of concentrating on the easier ways of making profits. Instruments like pre-emption of licensed capacity, and monopoly power, have been used for this purpose.

Many private sector units have a penchant for foreign collaborations, not only initially, but whenever and wherever they are permitted to do so. In the rubber tyre industry which has existed in the country for quite some time, every tyre unit, old or new, has a collaboration arrangement now with a foreign producer. Thus, a very long-standing producer and till recently a subsidiary of a British multinational, has now a collaboration with a Japanese concern in tyre-technology! Earlier, it used to pay as much 0.67 per cent of its turnover to its parent company for obtaining the benefits of the latter's R & D; and did not develop its own R & D in important fields on the

ground that the parent company could spend far larger amounts on R & D and the results were available to it at a comparatively modest charge.

The approach of Indian industry to foreign collaboration is well suggested by the fact that as soon as the government is known to be liberal in permitting such collaborations, there is intense competition to secure such agreements. There is little attempt to ensure that the technology is one which is suited to India's socio-economic environment or that the cost of the collaboration would be minimal. A recent Reserve Bank of India survey shows that out of a total of 1010 agreements (1970-73), 501 had export restrictions of some kind; and collaborations are supposed to help increase our export capability! In the years 1970-71 to 1972-73, the value of imports (excluding imports financed by foreign equity and also loans directly obtained by the companies) of foreign collaboration companies was double that of their exports. Recent data about important individual companies show that the position continues to be the same. But collaborations are the rage among our entrepreneurs.

At the same time, the record of most private sector units in the field of R & D has been quite poor. In spite of various tax concessions which have been offered especially in the last ten years to encourage R & D, very few units have gone in for a proper R & D organization, even those operating in areas where the rate of technological obsolescence is very high.

The preference for foreign collaboration, the inadequacy in absorbing foreign technology and in sustained technological upgradation through own R & D, has been the norm even for large units. No wonder then that most small units have had a much worse record in this respect. Quality control is still in its infancy in quite a few large scale units; in small ones, even in vital consumer areas like food and drugs, and in ancillaries and electronics, it is almost non-existent.

Another aspect which has received little attention from industry and industrialists has been that of adapting technology developed elsewhere to the Indian milieu. While, as a result of Government's insistence on reducing import content, considerable effort has been made especially by some large private units to replace foreign raw materials by Indian equivalents, there has been little effort to bring about changes in the production technology so as to economise in the use of capital, and substitute labour for capital, wherever possible. Looking at the matter historically, it is clear that not only were developed countries of the West using techniques which used much more labour in the earlier periods when they had a situation of relative scarcity of capital as compared to labour, but a country like Japan which followed them in its industrial development also used labour intensive techniques for long and still improved her competitive capacity. It is only in the post-Second-World-War period when Japan also began to face labour scarcity that labour saving techniques were adopted there.

Historically speaking, the business community in India had for long imbibed the tradition of using their incomes to build up more wealth, and using the wealth for further accumulation. Even the traders and businessmen who took to manufacturing in the period before Independence largely maintained their traditional mode of living and did not flaunt their wealth or use their income for affluent living. Leaving aside the tendency to spend lavishly on functions like marriages which is common to most Indians, the traditional businessman lived frugally and also maintained an essentially traditional Indian profile in his personal as well as business life.

Conservatism and patriotism both influenced most businessmen so that the earlier Indian capitalist showed not only the self-righteousness and ruthlessness but also the tradition of simple living which was, as R H Tawney had suggested, the hall-mark of the puritan industrialist in the early days of the Industrial Revolution. Imitating Western ways of living was more the practice of the civil servants and, to some extent, of the Western educated professionals. Only the executives of the few foreign companies that operated in India – most of them foreigners – had incomes as well as living styles comparable to or higher than those of the civil servants. The only other class which enjoyed large wealth and high incomes were the feudals – the princes and the zamindars. But their living standards had hardly anything to do with or influence on the upcoming educated classes.

In any case, in the discussions about future economic policy and income distribution, not only was the unjustified share of the feudal classes denounced but the civil service was considered to be a white elephant which the country could ill afford; and one of the aims of the Independence movement was to enforce in the civil service and in public life standards of living which would have a proper relationship with the potentialities and proprieties of the Indian economy.

But the whole scene underwent a metamorphosis after Independence. To some extent, the war period provided the interregnum in which businessmen and traders got accustomed to making very large profits, and tax evasion – not non-existant even earlier – became the norm. Unaccounted income could not be easily used for productive purposes and thus there was a greater propensity to use it for high living. After Independence, the political restraint of the Independence movement rapidly vanished. The Gandhian value of austerity, and ideas about the manner in which the leaders of community should live, began to give way. With the taking over of many foreign concerns by Indian businessmen, they also freely took to the ways of living of foreign business executives.

What is usually overlooked by business leaders is that the effect of high living by those at the top of the business world, and also their illegal transactions, on the working of the enterprises under their control has been disastrous. With the knowledge and, even more, the suspicion about illegal transactions indulged in by the bosses widespread among those working in the organisation, there is little respect left for those in positions of authority. What the Indian economy requires is a kind of puritan ethics of high productivity, sustained work and austere living; what has come to prevail is the idea of grabbing the highest income one can get, and not necessarily in return for productivity and efficiency. Responsible trade union leadership has come to be challenged and replaced by another kind who advocate the idea of bargaining hard for high wages and no or low production norms; and wherever the

D T Padekar

enterprises enjoy monopoly profits, they gradually accept such demands without much demur.

Thus, on the one side we have masses of people who remain unemployed, many of them receiving a pittance as daily wages in casual and unorganised employment. On the other, we have a kind of aristocracy of labour in a small number of well organized industries and service sectors. This, it needs to be remembered, is the logical result of the insistence, especially by those in the leading positions in India's private sector, of having standards of income and living which are unrelated to India's per capita income, and therefore consumption proprieties.

One supposedly positive aspect of a capitalist, free enterprise, economy is that there would be maximum scope for talent to find its proper place as a result of competition among enterprises for such talent. It is assumed that, unlike in a feudal society in which birth determines one's place in life, under capitalist free enterprise, there would be increasing equality of opportunity and even a person from very humble origins can rise to the top provided he has the potential and is ready to undertake the necessary effort. Has such a system developed in the private sector of our economy?

In a large majority of private sector concerns, not only do members of the controlling family enjoy a special status, but many times even those belonging to their caste or sub-caste, and their regional or language group. If one observes carefully, one always finds that, especially in key and trusted positions, people from the caste, sub-caste or clan of the masters are employed to act as watchdogs. There is also a tendency to employ people from one's caste and region even if the business organisation is located in quite a different region. The business leaders strongly oppose the "sons of the soil" type agitations as parochial and chauvinistic; but their own behaviour is usually one of showing special favours on such considerations. How can a modern economy based on open opportunity for talent be developed on this basis?

One can of course justify what is happening in the business world by making a reference to what is happening in our political and public life. Feudalism and dynastic succession continue their hold even in important political positions. But then, isn't modern capitalist enterprise supposed to be a pioneer for transforming a feudal into a modern society? Are our large private sector enterprises leading us in that direction? Are they not helping the build-up of a new stratum of oligarchs and zamindars? And in such a system, how can one expect the unprivileged employee to feel any responsibility for the successful conduct and continued growth of the enterprise, or the economy?

One expectation when making a late entry in the already developed world of modern industry is that the pitfalls indicated by the earlier countries would be avoided. But Indian industry does not appear to have learnt anything of the kind. Its record in avoiding ecological imbalances, pollution of water and air, and creating vast megacities is unenviable. In fact, the list of units contributing to pollution in Bombay and Calcutta as indicated by Pollution Control Boards reads almost like a who's who of the leaders of private sector industry; and the development of Nariman Point in Bombay can be cited as a notorious example of joint enterprise by politicians and businessmen!

Our new leadership is now eager to take India to the 21st century by way of technology and mode of living. As a foretaste of it, 70 per cent of the population is supposed to be already covered by the television network. (Of course, with 85 per cent of urban and 96 per cent of rural households having a per capita annual expenditure lower than the price of the cheapest TV set, how many can actually use it is quite another question). The private sector is eagerly cooperating in the endeavour, by providing large scale revenue to Doordarshan, through advertisements and sponsored programmes. In a country where punctuality and other disciplines of a modern economy yet remain to be imbibed by a large part of the work force, to sponsor popular programmes like sports events on weekdays, and to expect that workers in offices and factories will concentrate on their duties, appears absurd. But even a worse part of this recent imitation of "advanced" consumer societies is the wrong priorities and distorted consumption patterns the effectively organised sales effort is likely to create. Such a critical attitude to induced consumption has recently been indicted as "theology"; reducing consumption, it is said, means reducing production. But to my may be old-fashioned view, inducing consumption of unnecessary goods in a country where over one-third people do not get enough to eat is a sin.

The country is in a sorry mess today, almost forty years after Independence, with at least 37 per cent (if not more) in distress, below the poverty line; with the quality of life deteriorating in many cities and regions; with a growing number of unemployed, even among the educated; and with a general feeling of injustice, unrest and dissatisfaction growing among the people.

It is the fashion of the moment to claim that it was the over-regulation of the economy, the high taxation, and the restrictive approach which impeded progress. While this criticism has some merit, and some of the de-regulating measures are therefore justified, in my view what went really wrong was something more fundamental. We in the elite groups permitted increasing divergence to arise between our advocacies and our actions, our professions and our practice. While speaking about austerity, we permitted our class to indulge in affluent consumption. While speaking about public weal, we permitted individual, family, clan and other narrow interests to dominate our actions. And the private sector , instead of remaining a vigorous and useful but controlled instrument of the State, began to dominate it. Instead of the "intermediate regime" controlled by the *petit bourgeois* leadership gradually using State capitalism to move towards a more egalitarian and socialist-patterned system, it began to increasingly support the maintenance – and even the widening of the inequalities, the injustices, and the undue power and wealth concentrations of a capitalist order. This can prove disastrous for a country whose democratic traditions, federal unity and well-ordered economy are still not very deep-rooted.

The basic approach in our industrial policy was not controls and licences; it was that the policy would seek to attain the constitutional objectives of economic growth and social justice through the public sector dominating the economy from commanding heights, thus setting the path which private units will follow. While permitting private sector units as much operational freedom as possible, it was to be ensured that they fitted into the framework of the social and economic policy of the State. Not merely was concentration of economic power and growth of monopolistic tendencies to be encouraged. By being in command, the public sector was to reduce the scope for accumulation of wealth and large incomes in private hands, help reduce disparities in income and wealth, and ensure social mobility. But this example, and through regulation, the private sector was expected to follow.

In practice, what happened was that the public sector expanded, but took on the characteristics of a bureaucratic organization on the one side and the values of a capitalist enterprise on the other. Powers to regulate the private sector increasingly became instruments of extortion, with those in power filling their private or party pockets. The socialist objectives remained merely slogans to be used for deceiving the public. The private sector contributed to this denouement by using its corrupting influence and its power over the press.

Where do we go from here?

H K PARANJAPE

Dr Paranjape, a well-known economist, is at present a Jawaharlal Nehru Fellow. He was member of the Industrial Licensing Policy Inquiry Committee (1967-69), member of the MRTP Commission (1970-76), senior adviser at the International Centre for Public Enterprises (Ljnbljana, Yugoslavia) (1976-77), and chairman of the Railway Tariff Enquiry Committee (1977-80).

The bureaucrat

ONCE UPON a time there was a deserted village in which there was an old dilapidated house, in which there was an older rickety bureau, in which there were many many old papers, all crumbling to powder. A female rat was living happily in that bureau, playing with the papers as much as it wanted. One day, all of a sudden, this bureau-rat came upon the male cat which was living behind the opposite bureau, which was equally old and even more squalid.

But lo! that bureau-cat fell instantly in love with the bureau-rat, which naturally resulted in an instant marriage. Out of that wedlock was born the BUREAU-CRAT. Thus came to pass in this world the hybrid bureaucrat, an offspring of the bureau-cat and the bureau-rat.

The bureaucrat was a supreme blend of all that is bad in the cat and in the rat. It was as indolent as the cat and as dirty as the rat. It participated in every rat-race, but took cat-naps on other occasions. Like the cat, it had nine lives; but like the rat, it shunned bright light and preferred absolute darkness when in trouble.

It was equally at ease with rats and with cats, but talked like cats among rats, and like rats among cats.

When on a wall, it would remember its father — the bureau-cat — and no one could predict which way it would jump. But when it was chased, it would remember its mother — the bureau-rat — and take shelter in the nearest burrow or hole, twitching its nose all the while.

The bureaucrat had cat's whiskers, but only a rat's tail. When the bureaucrats fought amongst themselves, there would be much caterwauling, of course amidst the intermittent squeals of completely cornered rats.

The bureaucrat is a monstrosity of nature, and is therefore a profoundly scientific curiosity. It is very prolific and fertile. Its tribe has increased without bounds. It never believed in family planning, but only in planning families. Millions of its minions have come to occupy all the corners of the world, and, naturally, all the bureaus in all those corners. It has become urgently necessary to study the bureaucrat, its qualities, its eccentricities, its exploits — and its tantrums. Bureaucrats are of various types:

* Administrative service type
* Military service type
* Political type
* Commercial type
* Religious type
* Journalistic type
* Film world type
* Poetic and Artistic type
* University type
* Scientist type
* Technical service type, and
* Universal type

We shall study these types, and also some more evolving types, in some detail one by one, in the forthcoming issues.

-P KUMARASWAMY

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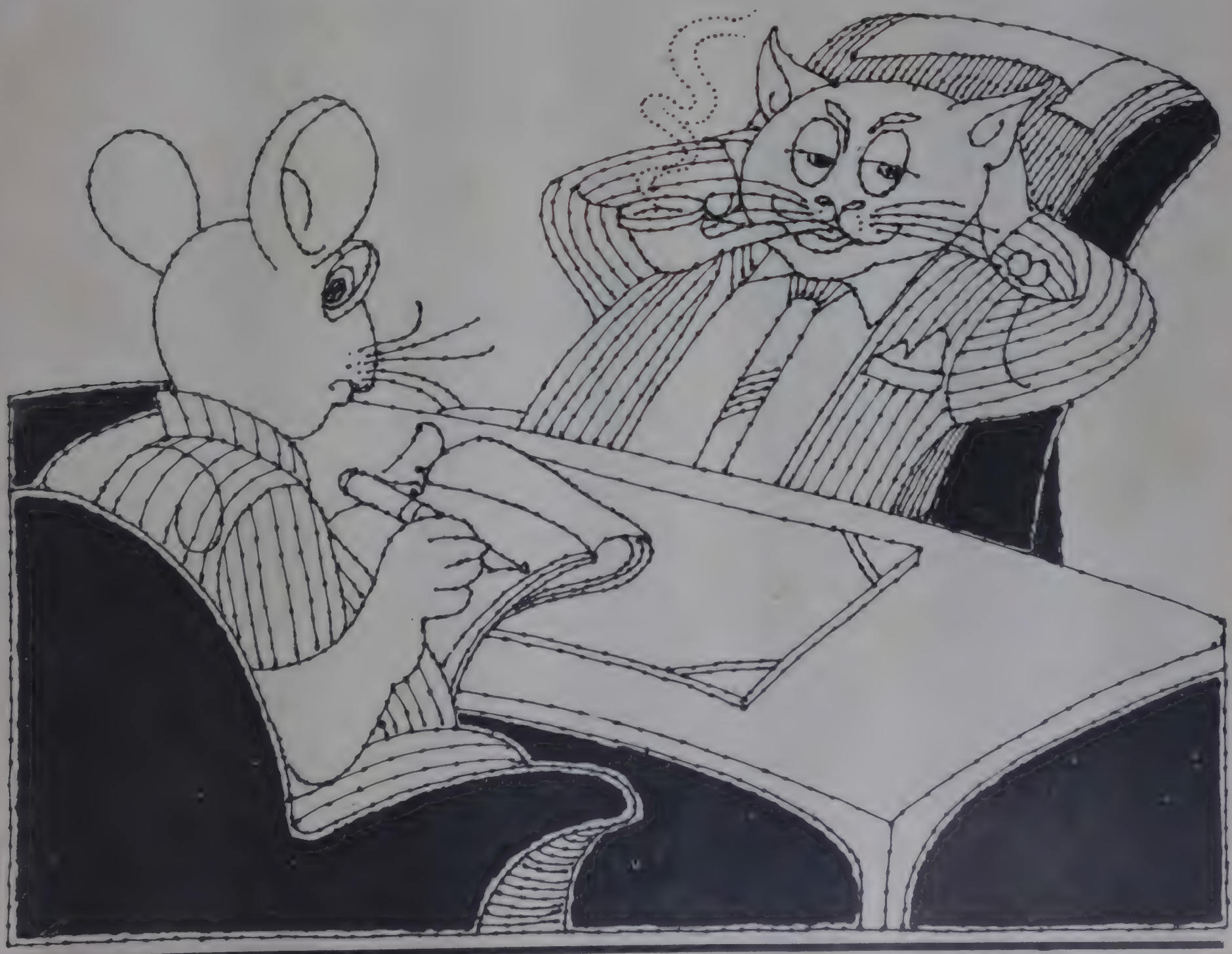

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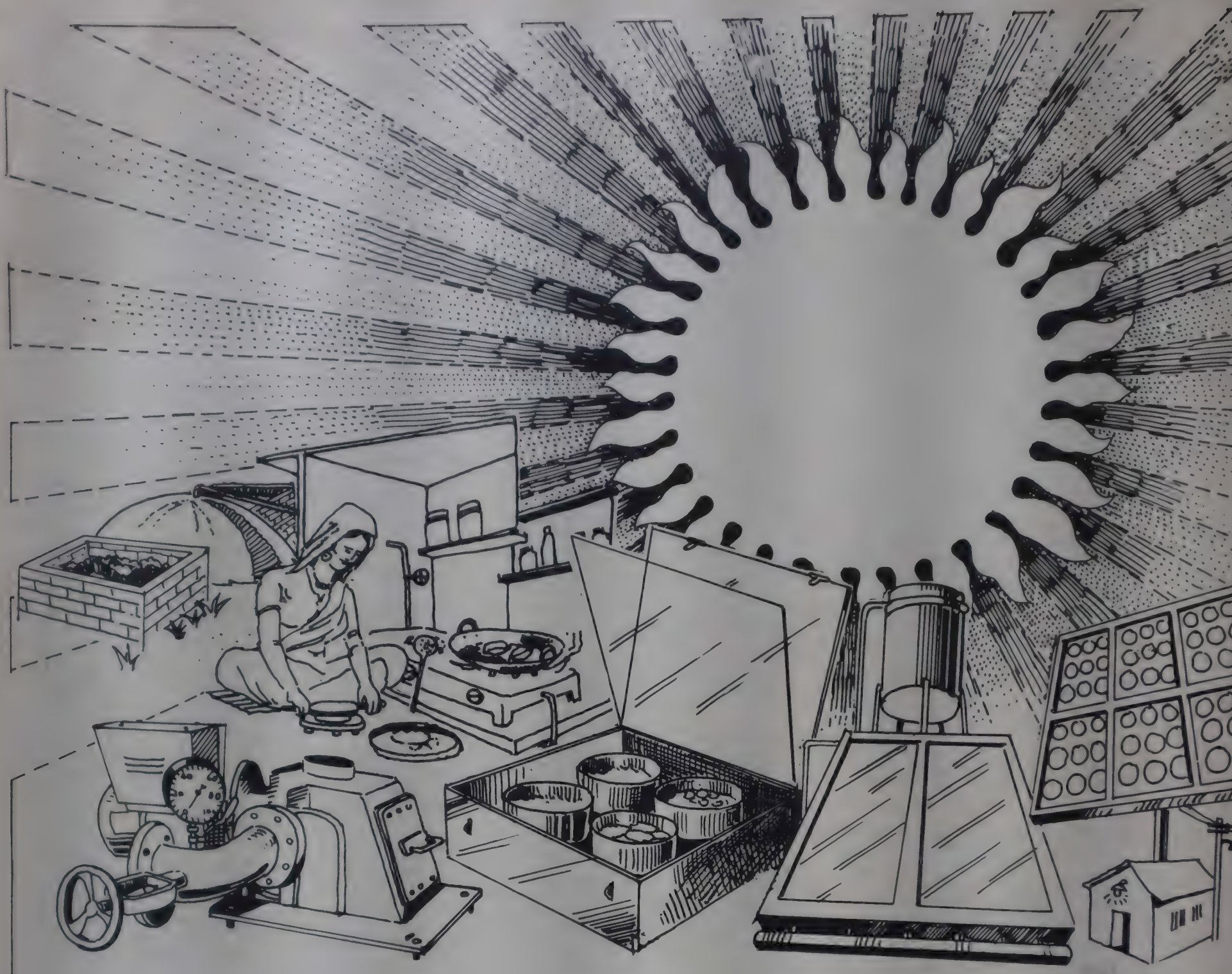

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DEVELOPMENT AS TERRORISM

SHIV VISVANATHAN

Science doesn't seem to have place for the defeated except as objects of experiment

D T Padekar

JOSEPH CONRAD was one of the great students of violence as something inherent in modern man's conception of the world. In a fascinating passage in his novel, *The Secret Agent,* the first secretary of the Russian Embassy explains the logic of violence to the anarchist, Verolac. He remarks that the power of terror should not reside only in the physical impact of the bomb, but should emanate further through the symbolic aura it creates. An ordinary bombing, he explains, is as banal as class hate. "But what is one to say to an act of destructive ferocity so absurd as to be incomprehensible, inexplicable, almost unthinkable; in fact, mad? Madness alone is terrifying, in as much as you cannot placate it either by threats, persuasion or bribes. Moreover, I am a civilized man. I would never dream of directing you to organize a mere butchery ... it would be really telling if one could throw a bomb into pure mathematics ... what do you think of having a go at pure astronomy?" The secretary asks the agent to blow up the Greenwich Observatory, the custodian of time. "The whole civilized world has heard of Greenwich. The very boot-blacks in the basement of Charing Cross station know something of it."

While Conrad thought of the act as senseless, he did not explore the possibility of modern science itself being a mode of violence or tyranny. His imagination failed to grasp the possibility of a lonely tribal striking a futile blow at Indian Standard Time or at the glass encased metre of ISI. The anthropology of the act eluded him.

What I propose to do in this essay is to lay out the descriptive characteristics of such an act. It involves, I believe, three separate realizations: (i) that modern science encodes a structure of domination and violence; (ii) that the violence implicit in science is not a pathology restricted to the fringes or the frontiers as in atomic physics or genetic engineering, but resides in its every-day manifestations; and (iii) that the acts of protest against such a structure inaugurates what has been called the insurrection of the "little knowledges". One has to interpret all these within the wider framework of the history of science.

Historians of science have been maintaining two parallel sets of registers. There is, first, the textbook histories of science as an impersonal method leading to the notion of order as collective truth. Accompanying this, however, is an act of bracketing, a ritual separation where theories like *racism* in anthropology, *orientalism* in linguistics, *IQ* in psychology, *social darwinism* in economics and biology are bracketed off as "pseudo-science" or as distortions of normal science. What I would like to suggest is an alternative explanation. The marauding genius of science needs these wider spaces for the playing out of its imagination. This collective unconscious constitutes an integral part of the scientific experiment. To mark it off saves science as a phenomena but contributes little to our understanding of it. It does not explain why these theories repeatedly recur in science. One can see this same trend in the modern discourse on development.

Development should be regarded as a scientific project. As a project, it is composed of four conceptions, together encapsulating the technocratic view of progress.

(i) *The Hobbesian project:* the conception of a society based on the scientific method;

(ii) *The imperatives of progress:* which legitimize the use of social engineering on all those objects defined as backward or retarded;

(iii) *The vivisectional mandate:* where the other becomes the object of experiment which in essence is violence and in which the infliction of pain is justified in the name of science;

(iv) *The idea of triage:* combining in it the concepts of rational experiment, the concepts of obsolescence and vivisection – whereby a society, a subculture or a species is labelled as obsolete and condemned to death because rational judgement has deemed it incurable.

The genealogy of modern science is often traced to the tracts of Bacon or Descartes. They were no doubt influential, but the triptych is only com-

plete with the work of Thomas Hobbes. If Descartes captured the philosophical expertise of the machine as imagination and Bacon the rules of the experimental method, Hobbes complements them with the conception of a society based on the scientific method.

For Hobbes, modernity demands a movement from the state of nature to civil society. For him, like the society of his time, the state of nature was seen as rampant disorder where "every man is enemy to every other man". "There is no place for industry, no culture of the earth, no navigation, no instruments for moving, no knowledge of the face of the earth, no account of time, no arts, no letters, no society." With no science and no society, "The life of man is solitary, poor, nasty, brutish and short." It is to combat this condition that civil society which is rational, scientific, stable and ordered is conceived.

The sovereign or state as the monopoly of terror and of the instruments of death is the axiom on which rational society is constructed. Society is based on the violence of the sovereign, but repeated violence makes society uneconomical. The role of science is to add to the fear of death the structure of quietude, of monolithic order, such that to be is to be scientific — in every sense of the term a subject and a citizen. The Hobbesian project has been the great dream of modern man. It underlies the logic of all technocratic totalitarianism whether of Lenin, Stalin or the new laboratory states of the twentieth century.

Modernity is a vision of conquest. Every structure of conquest needs a calendar, a liturgy of its power. To do so, it has to capture or rewrite time. The first project of modernity and of science as modernity was then to escape from its own past, replace the medieval cyclical theory of time which allowed for decadence and reversal by the notion of linear, irreversible time.

It is this notion of an ordained linear movement across this sequence which is defined as progress. It is also the basic assumption underlying the law of stages, present in the work of Spencer, Marx, Comte or all the other evolutionary schemas of science. As a result, other civilizations or tribal cultures are seen as "contemporary ancestors" (as for instance in a museum) — the past that the West has already lived out. The West, the modern West, is in turn the future these societies will encounter.

Such a model of progress implies that the increasing accumulation of science is seen as a sign of grace. The West as modernity contains the mandate of power and responsibility over the world left behind by history. It is science as the gaze that brings the primitive and the archaic back into contemporaneity. The latter then becomes the object of the experiment — the programme called modernization. As "scientific" projects, progress and modernization thus legitimate any violence done to the Third World as object.

The experimental method so crucial to modern science is not only a system of political controls but it incorporates a unique notion of violence — that of "vivisection". Within such a framework, the laboratory becomes a political structure and the basis of a wider vision of society. One can illustrate this with reference to the development of public health in India.

A 1727 engraving... the insane were beaten to drive sense into them

In September 1896, plague struck Bombay and raged without cease for 12 years and eight months culminating eventually in the death of thousands of people. Today it is remembered in medical history and commemorative stamps as a tribute to Haffkine after whom the plague research institute in Bombay has been named. Within the structure of medical discourse, Haffkine's work is regarded as one of the great justifications for vivisection. *The British Medical Journal* announced that Haffkine had arrived in India from the Pasteur Institute in Paris "to test on man the remarkable results which he had obtained on animals in the laboratory with reference to the cholera bacillus". The note added that it was struck by Haffkine's enthusiasm for the test. Simultaneously there was a plague in Egypt which is now almost forgotten. Sir John Rogers, who was then Director General of the Sanitary Department in Egypt, immediately instituted a series of sanitary measures. Persons found infected were isolated, put in quarantine, where they were fed and also compensated for the loss of time. Simultaneously, a whole set of sanitary measures such as limewashing of infected houses and disposal of garbage within the city precincts were carried out. The plague in Egypt ended within six months, the eventual death toll being a mere forty-five.

When the epidemic was raging in India, many doctors brought to Haffkine's notice the importance of instituting sanitary measures. But Haffkine represented what the committee called "the laboratory point of view". He rejected these suggestions and threw the entire weight of his scientific reputation to ensure that no sanitary measures were undertaken while his vaccine was being tried out. What is disquieting here is the notion of experimental test or control.

Vivisection, the inflicting of pain originally on "lesser animals" for the purposes of scientific research, received its impramatur in the writings of Descartes. The great methodologist believed that the cry of an animal was not due to pain but could be compared to the creaking of a wheel. This Descartian vision was succinetly carried forward, among others, in the works of Claude Bernard. The organism, he stated, had to be taken to pieces in the same way as a machine is dismantled. The hospital,

Often millions of animals are "sacrificed" wastefully to establish some minor fact

said Bernard, is only the antechamber of medicine, while the laboratory constituted its *sanctum*.

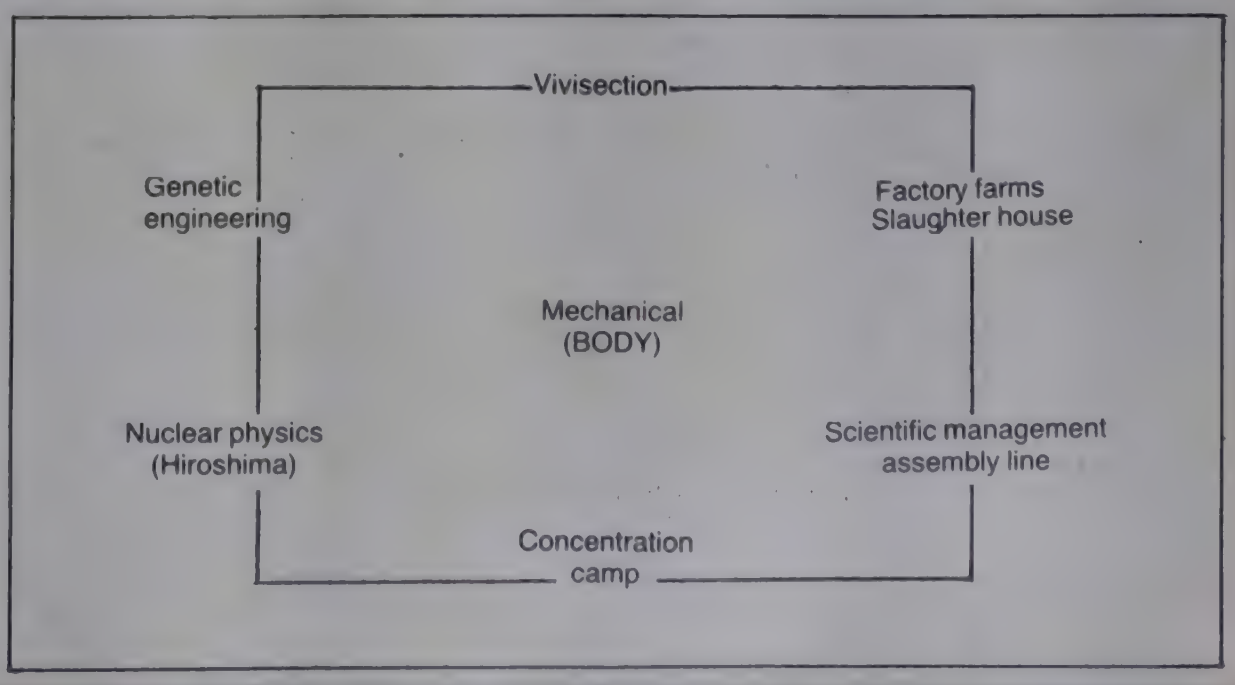
Bernard's work reflected the intrinsic violence of science, conceived as vivisection. Some of the early vivisectors might have been sadists, but Bernard exemplifies the schizophrenic attitude of pure "normal" science to the vivisectionist violence of science conceived as *method*. Bernard remarked that "the physiologist is not an ordinary man: he is the scientist possessed and absorbed by the scientific idea he pursues. He does not hear the cry of animals, he does not see the flowing of blood; he sees nothing but the idea and is aware of nothing but the organism that conceals from him the problem he is seeking to resolve."

It is necessary to quote Bernard because vivisection, which has acquired a paradigmatic status within science, has now become totally banal. The pervasive everydayness of it hides the metaphysical shock one would have experienced. Today, over a hundred million animals are used up in the pursuit of research every year, in experiments ranging from hair dyes to cancer research. Peter Singer cites a 1971 survey carried out by Rutgers University which provided the following estimates of the numbers of animals used each year in US laboratories: 85,000 primates, 500,000 dogs, 200,000 cats, 700,000 rabbits, 46,000 pigs, 23,000 sheep, 1.7 million birds, 45 million rodents, 15-20 million frogs, 200,000 turtles, snakes, lizards — a total of 63 million animals. One can add to it now a roll call of patients, prisoners, poor, inmates of old people homes and nameless peasants in the Third World.

The vivisectional socialization of science has been so extensive that even children regard it as a banal part of the educative experience, providing a pervasive sanction for evil. Gerald Carson cites the example of a child "who gouged out the eyeballs of house sparrows, punished them with electric shocks when they refused to respond to light and won a science prize for $200"

Opposition to science as vivisection has usually been dismissed by scientists as sentimental. But one must see it as a paradigm for generalized scientific activity extending towards wider domains of control, incorporating innumerable sets of violence within the genre of vivisection. This scenario is reflected in the following schema. One witnesses the violation of the body in the search for scienticized production and control. The violation of the body soon leads to the vivisection of the body-politic in theories of scientific-industrial development. These examples, one must note, are transforms of one another. The vivisectional code underlies and underwrites the violence implicit in all of them.

The schema shows that any effort to make a problem scientific carries within it the seeds of vivisectional violence. As a concrete example, one can begin with scientific management. Modern management has its origins in the vivisection of the animal body. The first assembly lines were developed in the slaughter houses. The meat conveyor belts in the packing industry anticipated the assembly lines of the Ford Motor Company. Braverman cites the following description of them. "The animal was surveyed and laid off like a map; and the men were classified into thirty specialities and twenty rates of pay, from 16 cents to 50 cents. The 50 cent man was restricted to using the knife on the most delicate parts of the hide, or to use the axe in the splitting of the backbone. In working on the hide alone there are nine positions at eight different rates of pay. A 20 cent man pulls the tail, a 22½ cent man pounds another part of the hide...." The dissembling of the body later became the model for the assembly line. It was only a short step then to vivisecting body motions to establish the basis of scientific management, of what is known as "Taylorism", named after Winslow Taylor, the father of modern management science. The Taylorist experimental attitude is captured expecially in his descriptions of his object of study, the Dutch worker, whom he calls Schmidt. Taylor records how he decides to instruct Schmidt in order to determine the mechanics of work. He tells him, "you will do exactly what this man tells you tomorrow morning till night. When he tells you pick up a pig (iron), you pick it up and walk, and when he tells you to sit down and rest,you sit down. You do that right straight through the day. And what's more, no back talk. Do you understand that? When the man tells you to walk, you walk; when he tells you to sit down, you sit down and



Testing the effect of lower pressure on a prisoner in a Nazi camp. He died when his lungs burst in the thin air

Nazis used prisoners to find out what happens to a human being immersed in icy water for three hours

you don't talk back to him." Taylor himself admitted that he was surprised to find a human animal so amenable to experiment.

What appears as ordinary scienticized production techniques reflecting the violence of vivisection acquires new power when juxtaposed to the next two cases of vivisection, the concentration camp and the bombing of Hiroshima.

The history of the excesses of the Nazi regime have been explained in terms of the individual psychopathologies of Hitler or the authoritarianism inherent in the German culture. Yet these studies do not fully explain the particular nature of violence as it occurred in the concentration camps. Part of the answer for the pedantic orderliness of the concentration camp can be understood by grasping the fact that its violence was a direct consequence of the normal science of the time.

The concentration camp had its roots in the nature versus nurture debates of the time. Eugenics was a part of the normal science of the time. In fact, as many as eight universities in America including Harvard, Cornell, Brown, and Northwestern had established departments in the subject. The mass killings of patients in the hospital was a direct application by doctors of established eugenic and psychiatry theory. Many of these doctors were outstanding intellectuals. The mass killings had all the workings of a community psychiatry project involving a network of mental hospitals, university professors of psychiatry, director and staff of the hospitals voluntarily working out the normal science of their scientific theory. The first concentration camps that came into being were seen as experiments in re-education. The doctor-psychiatrists who guided it looked upon it as an attempt to eliminate "useless eaters" — the mental patients. It was only after the basic methods of killing were worked out in these hospitals that the gas chambers were dismantled and moved to other locations. This time the "inferior materials" were Jews, gypsies and Poles.

The concentration camp was an industrial research laboratory organized completely by doctors and scientists. In fact, histories of synthetic chemistry which celebrate the synthesis of ammonia and indigo fail to emphasize its complementary role in the organizations of these camps. It is in this context that I want to establish a parallel, not often considered, between a paradigmatic scientist like Winslow Taylor and the great Nazi executioner, Adolf Eichmann. I want to suggest two points. First, that Eichmann thought of himself as a scientist-bureaucrat. And second, that the banality of Eichmann's evil lay in his scientific attitude. Eichmann deserves to be recognized as a Winslow Taylor of the concentration camp. Let us not forget that the originators of the assembly line and Eichmann confronted the same problem — the management and disposal of the body. The concentration camp operated on the same logic, only the materials handled were human hair, teeth, skin, nails and bones.

The last example that I wish to discuss is the bombing of Hiroshima. The bombing of Hiroshima embodied the violence of vivisection at three phases of its career. First, in the very decision to bomb the city; second, in the attitude to the survivors of Hiroshima and third, in the continuities of nuclear research itself.

Freidrick Wertheim in his *Sign for Cain* points out that there is a persistent myth that scientists as a group were against the dropping of the bomb. He contends that the leading scientists not only helped the government in making the decision but picked Hiroshima and Nagasaki as experimental sites. The cities were free of the devastation of incendiary bombs and were thus appropriate sites for the scientific evaluation of the nuclear impact. But what is more frightening is the general absence of atonement after the bomb. In fact, in *The Children of the Ashes,* Robert Jungk shows that scientists saw in it new possibilities for science. The city became in their eyes an industrialized table of symptoms to be subject to the clinical gaze. Jungk describes scenes at the Atomic Bomb Casualty Clinic (ABCC) where patients were studied in a Taylorist fashion: "thumped, had light shone in their eyes, be photographed, pumped full of serum". None of the specialists ever explained why or with what purpose all this was done to them. If a patient asked "what do you advise doctor? What can I do to get well again?", the reply was always the same, that the clinic was not a therapeutic establishment but a research institute. The disjunction between research and healing is implicit in the vivisectionist act. One is reminded of the statement of the French physiologist Charles Richet, "I do not believe that a single experimenter says to himself, when he was giving cure to a rabbit, or cuts the spinal marrow of a frog, that here is an experiment that will relieve or cure the disease of some men. No, in truth he does not think that. He says to himself, I shall clear up an obscure point. I shall seek out a new fact."

The third fact that startles one about Hiroshima is the return of the scientists, some of whom who had protested against the bomb, back to these laboratories. Jungk cites the case of the brilliant Hans Bethe, who had condemned the bomb as anti-Christian and genocidal. Yet a few years later, Bethe became one of the enthusiastic exponents of the H-bomb. Such macabre enthusiasm can only be understood by focussing on the internal structure of science as a mode of cognition, where violence is justified in the objective pursuit of knowledge. There seem to be no

internal checks to its cognitive imperatives.

Villagers Die in Bhabha City — *Times of India* headline.

I sometimes wonder what is worse
A secret or a lie
A word unspoken or left unsaid
When either way a man is dead.
I still maintain,
It is not death that is important
But the manner of dying
Like a child's first poem
Wiped by a careless eraser.

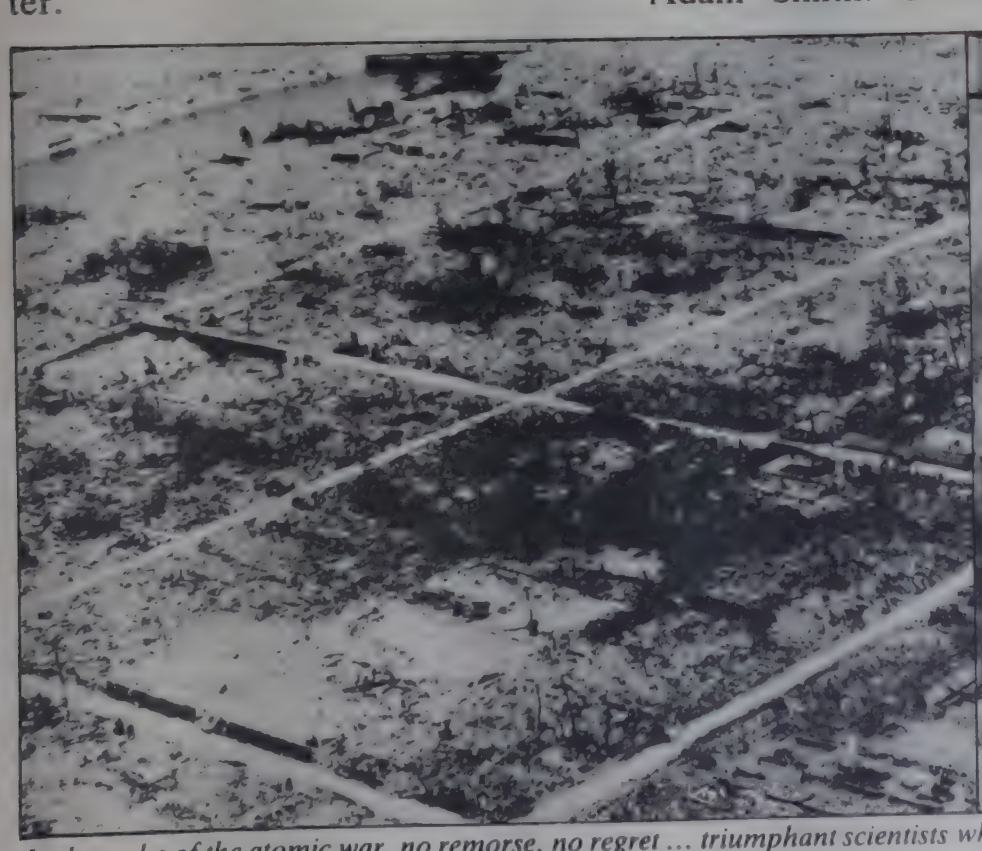
Lurking quietly within modernity as a scientific project is the idea of "triage". It has been the silent term mediating between the ideas of vivisection and progress. Vivisection as an experiment has implicit within it the notion of indifference and progress implies the idea of obsolescence. Triage as a concept interweaves these ideas as the obsolescence of those one is indifferent to. With the reappearance of triage as a formal concept, modernity has come full circle. It involves the notion of science as described in this essay. Science once felt that these societies had no history; today, it seems to have decided that they have no future. If the tribal was once whipped into modernity because he was a savage, today he is being bludgeoned back as being incapable of science. The decision in both events is articulated as a part of rationality as discourse. Whole societies and cultures are now being destroyed because they are considered refractory to the scientific gaze. Triage is the final abandonment of modernity as a universalizing project. The Western encounter with the non-West ends in its eventual logic as erasure of the latter.

Etymologically, *triage* is a French word which refers to the act of sorting. It acquired a certain stability in medical dictionaries as the method of screening patients to determine priority of treatment particularly when the demand for medical treatment outran the supply of medical facilities and personnel. Richard Rubenstien, in his book on triage, cites an example of such a process. It relates to the manner in which scarce penicillin was distributed among American soldiers during World War II. Rubenstien explains, "Some of the stricken men had received their wounds in battle, others in brothels; it was decided only soldiers with veneral diseases would be given penicillin, even if it meant that some of the wounded would die without it." The rationale was as follows: as those with broken bodies could not swiftly resume military duties, even with penicillin, those with veneral disease were given the penicillin as they could be despatched to the front in a few days.

Today the concept of triage has moved out of the confines of the hospital and acquired a wider socio-political connotation. It is the history of this wider notion of social triage that we must seek to construct.

Science has no place for the defeated except as objects of an experiment. The rudimentary notion of social triage has always been there. One can trace it as far back as the Benthamite projects in England. Triage represents a notion of obsolescence beyond that involved in the free market. The obsolescence created by the market has been chronicled in the writings of political economists since Adam Smith. Social triage differs from it in that it is the willed act of a state such that a target group, such as a minority, within its territory is defined as dispensable. The decision must also be articulated on rational grounds. Triage is genocide but it involves in particular the rational imposition of death on those regarded as refractory to the scientific gaze. One can cite a series of examples to elicit out its particular quality.

With the impact of the Enclosure movement in England, peasants became an uprooted class. The poor as vagrants, lunatics, criminals, even as children were considered as refuse and regarded as expendable. Children in particular were used in a large number of hazardous jobs. Bentham visualized a grand scheme — never operative — whereby those classified as refuse: children, lunatics, vagrants, were placed in a total institution, subject to complete surveillance and harnessed as work units by the state. Richard Rubenstien notes the theoretical continuity between Bentham's organization, the Panopticon, and the attempts by I G Farben to utilize death camp labour for the production of synthetic rubber. Both were efforts to rationalize the use of those society had defined as waste: the poor as "refuse" in Bentham's time, and the "useless eaters" in Hitler's Germany. The notion of triage goes beyond the rational utilization of such categories of people, into the deliberation on their death as disposal. The Benthamite project embodied in the Poor Houses sought to rationalize philanthropy as a project. Triage goes beyond aid as tutelage to aid as erasure. There are two separate processes of sorting here. The first involves



In the wake of the atomic war, no remorse, no regret ... triumphant scientists who did it: among them Enrico Fermi, extreme left front row, and Leo Szilard in a raincoat

the classification and exploitation of marginals in a society. The second centres around the elimination or death of those regarded as marginalized and obsolescent. The concept of social triage is primarily restricted to the second event.

The re-emergence of triage within the debates on development has to be constructed across two grids. The first centres around the debates regarding the coming of the post-industrial society and the second around the resurgence of the new reductionism in sociobiology as a discipline.

Krishan Kumar in a fascinating essay has referred to the spate of conceptual schemes plotting out the future of the industrial West. Predictably what is central to such societies is the centrality of theoretical knowledge, the primacy of theory over empiricism, the fact that theoretical formal knowledge provides the dynamics of innovation as expressed in the synthetic chemistry or the materials sciences.

What is interesting about these descriptions is not their detailed anatomy, but their silences. There is a feeling that the Third World is irrelevant, that the new developments in electronics, solid state physics and chemistry had rendered it unnecessary. Science as a source of surplus has enabled the modern West to escape from the Third World for its reliance on raw material or labour. The Third World is now conceived as "an area for tourism or for the siting of some of the more polluting industries of the world."

This process of exorcism is abetted by the legitimation provided by sociobiology in the works among others of Garret Hardin who acquired a lot of prestige in the West as an ecologist, through highly influential papers: *The Tragedy of the Commons* and *Lifeboat Ethics*. If nuclear holocaust had its macho rationalists in Herman Kahn, development as triage had its equivalents in Garret Hardin. The two papers are like parables with a Euclidean lucidity about them. Once you accept the axioms, the logic of the world they unfold follows ruthlessly. Therefore it is the basic assumptions that we must map.

First, Hardin's work posits an opposition between individual greed and social good and believes that the only solution is the Hobbesian one of coercion. Second, he holds that morality or humanism are no substitutes for hard-headed science either in the short or long run. In fact like other sociobiologists, he sees altruism as pathogenic to survival. Third, he fails to encode the opposition between biology and culture in cosmological terms. He thus lacks the conception of an ecologically coded society, a vision of a society that sees science as a part of the sacred, of man as a fragment of the cosmos. The two papers can now be read as successive chapters of one plot.

The formulation that Hardin offers is basically a Hobbesian one. The commons is any physical facility which is commonly owned or used. It can be an ocean, a lake, a forest or a prairie. The logic of the commons unfolds as follows. The commons is a state of nature, where every man seeks to maximize his individual gain. Initially, it was a period of abundance. The problem begins in a situation of scarcity. As each individual pursues his own interest, as individual utilities are maximized, there is an increasing threat to the social good. The eventual result is the degradation of the commons. For Hardin, like Hobbes, an appeal to conscience is futile. Only "mutual coercion, mutually agreed upon by the majority of people affected" will do. What is missing in Hardin's notion of the commons is the idea of *communitas*. Any reading of anthropology beyond the anthropologically suspect work on the *Ik* tribe would have shown Hardin that traditional communities avoided the tragedy of the commons because the management of the commons was a matter of the total community, it was not a matter for the individual.

Hardin's study of rationality and the commons also lacks a concept of communitas as a sense of the sacred. Rationality, to Hardin, borders on disenchantment, an absence of the sacred. In Hardin's scenario, the grammar of a wider cosmic view is totally missing. The fact that societies have to be looked on as a wider relation between man, nature and God is alien to Hardin. He describes the earlier period of the commons in a manner that would leave any tribal aghast. "A hundred and fifty years ago, a plainsman could fell an American bison, cut out only the tongue for dinner and discard the rest. He was not in any important sense being wasteful. Today with only a few thousand bison left, we would be apalled at such behaviour." The real tragedy of the commons is captured more poignantly in this sentence than in the rest of the essay. It shows that Hardin's Hobbesian rationalist science, embodied in planning, has no conception of the sacred. As a result, ecology becomes a managerial science, mopping up after industrialism rather than a cosmic

Destruction of the commons

view of the world. Affinity to nature is seen more as humanist poetry rather than as axiom for science. Hence, the tragedy of the commons is in fact the tragedy of rationality and science, of a worldview which has so lost its sense of the sacred that it fails to see that science — rationalist, hegemonic, value neutral, schizophrenic — have become the major anti-ecological force today. Like the scientist's own invention, Maxwell's Demon, science today stands as the major cognitive gatekeeper preventing a move to a more sacred and genuinely ecological vision of the world.

It is this that brings us to the second essay of Hardin, *Lifeboat Ethics*. The Leviathan that was once a commons has become constricted into a lifeboat. "Each rich nation can be seen as a lifeboat full of comparatively rich people. In the ocean outside each lifeboat swim the poor of the world, who would like to get in." What should the lifeboat passengers do? The questions are simple. Is aid necessary to these starving people? Should America aid the people of Ethiopia? Is aid as altruism rational?

The background to these issues was the controversial work of the Paddock Brothers, *Famine-1975*. The Paddocks argued that since America accounted for more than half the cereal grain in international trade, it had to decide who it must save. They recommended a system of *triage*, where the most hopeless nations were to be left without food. Hardin agrees with them and goes even further in criticizing the establishment of a world food bank to rescue starving nations. For Hardin, the poor are irrational, superfluous, multiplying much faster than the rich.

Hardin finds individual altruism even more pathological. For Hardin, altruism can only exist on a small scale, over the short run. Other sociobiologists add that altruism as universal love are concepts which do not make any evolutionary sense.

Underlying both the notion of the modern state and modern science is a monolithic worldview. The tragedy of modernization in the Third World is doubly violent. It has sprung not only from the violence of the West through colonialism and science but also from the modernist impulse of our elites, internalized without a clue to its doubts or its geneaology. Independence has thus turned out to be literally a celebration of science. If it was "a tryst with destiny", as Nehru dubbed it, then destiny "belonged to those who made friends with science". As dam, laboratory, railway or hospital, it becomes a basic *test* of statist goals and scientific endeavours. Today one realizes that such innocence has become ironic. Science has failed to deliver. Yet science continues to be the pursuit of the state, the energy for the perpetual machine of statist endeavours. Scientific projects, as big science, are an integral part of the Big-Government model of today.

There is a deeper issue here. Science is not just a sacred cow, it is a fat one and the elites realize that it provides legitimation for their greed. The parasitism of elites feeding on technological projects, growing fat on bribery, fixing and contracts is proverbial. The symbiosis between the state and science has several elements within it. We shall elaborate it with examples from irrigation projects.

We shall take as our text, Goldsmith and Hildyard's *The Social and Environmental Impact of Large Dams,* supplementing it with examples from nuclear energy.

The inhabitants of the Third World, and animals, are often considered inferior beings

Underlying modernization is a substrata of intolerance. The variegated traditions of the Thrid World — nomad, tribal, pastoral, peasant — have to be bulldozed into a flatland called modernity and there is little time for consultation. A Sudanese politician summed it well when he remarked, "If we have to drive our people to paradise with sticks, we will do so for their good and the good of those who come after us." So confirmed is the elite in its belief in progress that there is an authoritarian tilt to it. Not all cultures are as ruthlessly clear as Russia, where the KGB is responsible for water projects. The logic is clear, for such projects involve resettlement. Most development projects are presented as a *fait accompli* to the people. To the laboratory state, these people are not scientists, but ethnics practising styles of life-agriculture, medicine, crafts which are refractory to science. According to the logic of development, they must either acculturate or disappear. The laboratory state must break the rituals of tribalism and traditional farming. More than the bloodiness of wars, it is the banality of development as peace that has created refugees. The list is awesome. Ghana's Volta Dam saw the evacuation of 78,000 people from 700 towns and villages. Lake Kingi in Nigeria displaced 42,000, the Aswan Dam 120,000, the Kariba Dam 20,000, Turkey's Keban Dam 30,000. The Panon Dam in Vietnam could well uproot 500,000 people and the Three Gorges Dam in China, an estimated 2,000,000. In Phillipines, 40 new dams will displace 1.5 million people. Closer home, the dams in the Bastar area will inundate 1,70,000 hectares of land. It is progress as a scientific mandate that justifies the violence of such displacement.

What we are in fact confronting here is development as slow genocide. The irony of the tribal-peasant as refugee becomes even more poignant in the India of today. At one end, the peasant and tribal as native is defined as a squatter on his own ancestral land, confined to refugee camps called parks. At the other end, the laboratory state invites non-resident Indians, particularly scientists and engineers, to set up new industries. It is establishing technology parks and science cities for them. Today, to be scientific is to *be*. The tribal as native is a refugee while the non-resident Indian as scientist is defined as more than a citizen

Endemic to all such technocratic projects is the idea of Haussmannism. It can be defined as any act whereby a mechanical scheme — a plan for a city, a factory or a dam — is imposed on a culture without any consideration to the traditions of the community. The term derives from the activities of the French planner, Baron Haussmann, who imposed such a mechanical grid of roads on Paris after the commune. In Haussmannism, the technocrat is the leviathan imposing the flatland of mechanical order on the varieties of tradition or nature. The resettlement activities of technocrats like Jagmohan during the Emergency — tantalised by the

Haussmannian vision — could be cited as another example.

For the native in the refugee camp, death is a slow process. Only for the older, the moment of disruption is also the moment of dying, for few can make the transition to the new regime. For the living, catastrophe as imagination acquires new dimension. As the authors remark, "there is scarcely a scheme in existence which has avoided the twin problems of cultural disruption and social alienation. The notions of market or of science are poor lenses to recognize the sustaining relation between people and their land. For the market, compensation terminates the contract. For the scientist-technocrat, the development of this land is regarded as inevitable. Neither market nor science can capture the symbolic universe of the peasant-tribal.

When Guyana's *Akawaio* Indians were asked "to contribute to development by vacating their land", their headmen wrote the following letter to the Prime Minister, Forbes Burnham.

> "This land is where we belong — it is God's gift to us and has made us as we are. This land is where we are at home; we know its way; and the things that happen here are known and remembered, so that the stories the old people told are still alive here ... This land is the place where we know where to find all that it provides for us — food for hunting and fishing, and farms, building and tools, materials, medicines. Also the spirits around us know us and are friendly and helpful ... If we had to move, we would be lost to those who remain in other villages. This would be a sadness to us all, like the sadness of death."

What was an appeal, is today an obituary as the obsolescence encoded in progress had no place for sacredness as memory.

The movement from obsolescence as cultural destruction to triage as erasure is a short step. The most moving case is the systematic elimination of the *Ache* Indians in Paraguay, in the so-called forest clearance programmes. Behind it is the plan for building one of the world's largest hydroelectric power plants. To the giant corporations and its agents, the Ache Indians are inconvenient. But the forest must be cleared and Indians hunted down. Richard Arens in his *Genocide in Paraguay* describes it thus:

> "Men, women and children are being indiscriminately mowed down in such hunts. The preferred weapon of the massacre was the machete which saved the expense of bullets. Those willing to accept unadulterated slavery might also be kept alive at a subsistence level and without medical attention. The majority of those left in the reservation succumbed to despair and disease. The use of their language was discouraged, their traditional music prohibited ... About one half of a recently captured band (of Ache's on a reservation) was liquidated by the *conscious withholding of food and medicine.*"

The elimination of the Ache Indians has raised in a fundamental way the problem of development as genocide. The process of "resettlement"

Volunteers of the chipko movement hugging a tree to save it

involves slow death through deculturation. It falls within the clauses of the genocide convention. Item three of the genocide convention of the UN includes under its ambit, "Deliberately inflicting on the group conditions of life calculated to bring about its physical destruction in whole or in part."

This notion of calculated dispensability, of erasing people from the wider commons has several dimensions. Firstly, triage can treat a present generation as dispensable *vis-a-vis* the future. The outstanding example would be Stalin's planocentric vision where one generation was regarded as dispensable. The current experiments in nuclear energy, especially the storage of nuclear wastes, literally condemns a future generation. It is estimated that nuclear wastes, unlike other biodegradable materials, remain active for 50,000 years. The transfer of pollution prone industries to the Third World is yet another example of triage. The recent example of China agreeing to store German nuclear wastes in the Gobi desert in return for foreign exchange illustrates such a case. Triage operates in another form in the present style of nuclear testing. While Europe is no longer a site for nuclear testing, the Third World as space is regarded as formally dispensable. Closer home, journalists have shown how policies of triage have been employed against seasonal workers repairing leaks at the Bhabha Atomic Research Centre.

What we are witnessing today is literally a civil rights movement against development as terrorism, the recognition that the modern state committed to science has become the prime anti-ecological force in the world. What development projects like dams or nuclear reactors reveal is the necessity of new notions of civil rights. We need new concepts which grant rights to the future generation. Recently, it has been suggested that we recognize rights in natural objects — like trees, forests, rivers and seas. But contractual or legal systems cannot serve as the basis for ecology. One needs a return to the sacred, where community recognizes its moral responsibility for its environment.

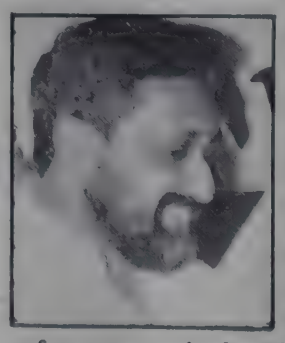
The Chipko movement is a superb example of such a consciousness. It inaugurates one of the finest challenges to the scientific regime. It pinpoints that rationalist science is a repressive regime. In addition, it shows that tribal cultures and peasant agriculturalists are more ecologically sound than the modern scientist. We are forced to confront the fact that Green Revolution reductionism is no substitute for ecologically sensitive traditional practices.

It is this insurrection of the local knowledges which demands a recognition of the knowledge of the sacred and at the same time of the highly pragmatic folk knowledges of the people, providing the crystal seed around which the challenge to the laboratory states of modernity has already begun.

In the meanwhile, the reality is this:

I saw them bury a dead child
In a cardboard box
(This is true, and I don't forget it)
On the box there was a stamp
"General Electric Company
Progress is Our Best Product"

– Louis Alfredo Arrango
Guatemala, 1965



Mr. Visvanathan is a social anthropologist and currently visiting fellow, Centre for Study of Developing Societies, Delhi. His book Organising for Science *was reviewed in SCIENCE AGE June 1985.* *The above is an edited version of a paper which will appear in a forthcoming book,* On Science, Domination and Violence *edited by Ashish Nandy.*

FORESTS AND RAINFALL

SULOCHANA GADGIL C R PRASAD

A FEW years ago there was widespread drought in Kerala. Thousands of coconut trees were affected and the price of coconuts soared. Some attributed the drought to the extensive deforestation carried out in the preceding years. The very next year, however, the rains were good. Immediately, a proponent of the Kerala timber lobby concluded that since continued deforestation had led to such a good rainy season, deforestation had no adverse effect on rainfall.

This illustrates the kind of debate that has been going on in India over the nature of the impact of forests on rainfall. The major flaw in both these arguments is in ascribing year-to-year changes of the rainfall to changing land surface conditions. In fact, we believe that these fluctuations of the monsoon on the interannual scale would occur even if the tree cover was maintained absolutely constant. The question is whether the land surface conditions change the mean climate around which these fluctuations occur.

It is well known that the nature of vegetation depends on rainfall. But is the converse true? Does a change in plant cover lead to a variation in rainfall?

From the 19th century onwards, there has been a massive depletion of tree cover in India. Yet, over this period, the variation of rainfall over the country as a whole has not been large. The standard deviation is only about 10 per cent of the mean and the worst drought had a deficit of only 25 per cent. The variation is dominated by large changes from year to year, representing oscillations between droughts and good monsoon years. Furthermore, the average rainfall appears to have increased in the early part of the century and decreased from the mid-sixties onwards. Thus there seems to be little ground for the widespread fear that deforestation will result in a substantial decrease of rainfall over the country as a whole over periods shorter than a century.

However, in the past decade, we have become increasingly aware of the fact that the nature of the land surface plays an important role in moulding the climate of certain parts of the tropics. These are the semi-arid regions surrounding the deserts. (It was the worldwide drought of 1972, followed by a major failure of the rains in the early 1970s, which led to this awareness.) In a pioneering study of this problem, J Charney et al (1977) first pointed out the presence of a biogeophysical feedback in which a decrease in the plant cover leads to a change in the climate — specifically a decrease in the rainfall — which in turn leads to a further depletion of plant cover, or desertification, over these marginal regions. We therefore expect large-scale deforestation of certain sensitive regions to lead to progressive desertification.

Why should deforestation affect rainfall?

Rainfall is associated with the ascent of moist air and the major rainbelt in the tropics is located over the radiative heat source (see box). It is easy to understand how plant cover can influence rainfall when we note that with a decrease in plant cover, the albedo or reflectivity of the land surface and the dust content of the atmosphere increase. Both these factors imply a decrease in the solar radiation received at the surface. Thus we expect the strength of the radiative source to decrease with a decrease of plant cover. Also the moisture in the air is likely to be greater in a forested area. Particularly in the semi-arid regions around the periphery of the rain-giving system, namely the ITCZ (see box), the balance is rather delicate and could be easily affected adversely if the radiative source strength decreases due to large-scale deforestation. Since the plant cover itself depends on the rainfall, this will lead to a further decrease in plant cover. In the presence of this biogeophysical feedback between the land surface conditions and the rain-giving system, an initial decrease of plant cover will trigger a process of desertification.

Such arguments can only suggest the nature of impact of a change in plant cover. What actually happens in the complex dynamical system whose

end-product is rainfall depends on a number of other factors. They influence the chain of events in the biogeophysical feedbacks such as the local evapotranspiration, soil moisture and other feedbacks operating in the system, for example, cloud-radiation feedback. Recent observational experiments in the Amazon region indicate that as much as 15 per cent of the moisture content of the air above this region comes from local evapotranspiration. Such factors are thus bound to play an important role in determining the circulation and rainfall patterns.

Model studies

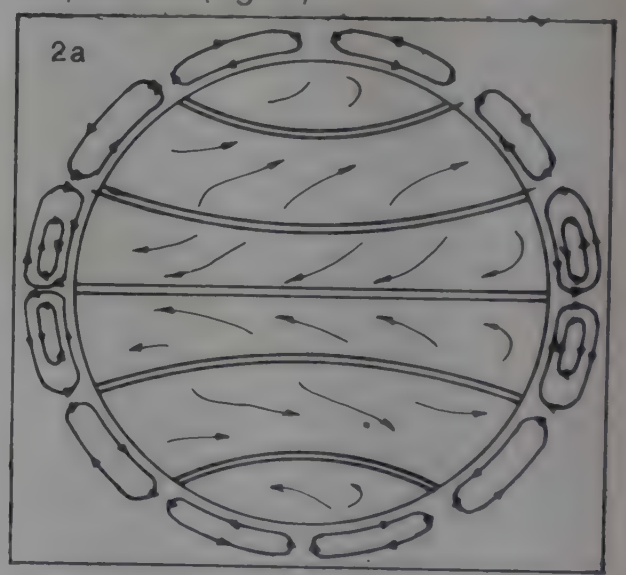
In the last few years, quite a few realistic models capable of simulating the mean tropical circulation and rainfall patterns have been developed. The different effects of deforestation are simulated by a change in the albedo and/or soil moisture etc and the results of the model run are compared with the control run (in which there is no deforestation so to speak) theoretical studies provide an ideal tool for testing the impact of deforestation on tropical rainfall.

The first such study was by Charney and co-workers. In the control experiment, the albedo of the deserts was taken to be 35 per cent and of the rest of the ice/snow free continents to be 14 per cent. The albedo of three regions adjacent to the deserts, including Sahel and Rajasthan,was changed from 14 per cent to 35 per cent to simulate loss of plant cover. It was found that the rainfall over Rajasthan decreased by about 50 per cent. This general trend of a decrease in rainfall resulting from an increase in albedo has been confirmed by later studies. A decrease (increase) in the evapotranspiration is

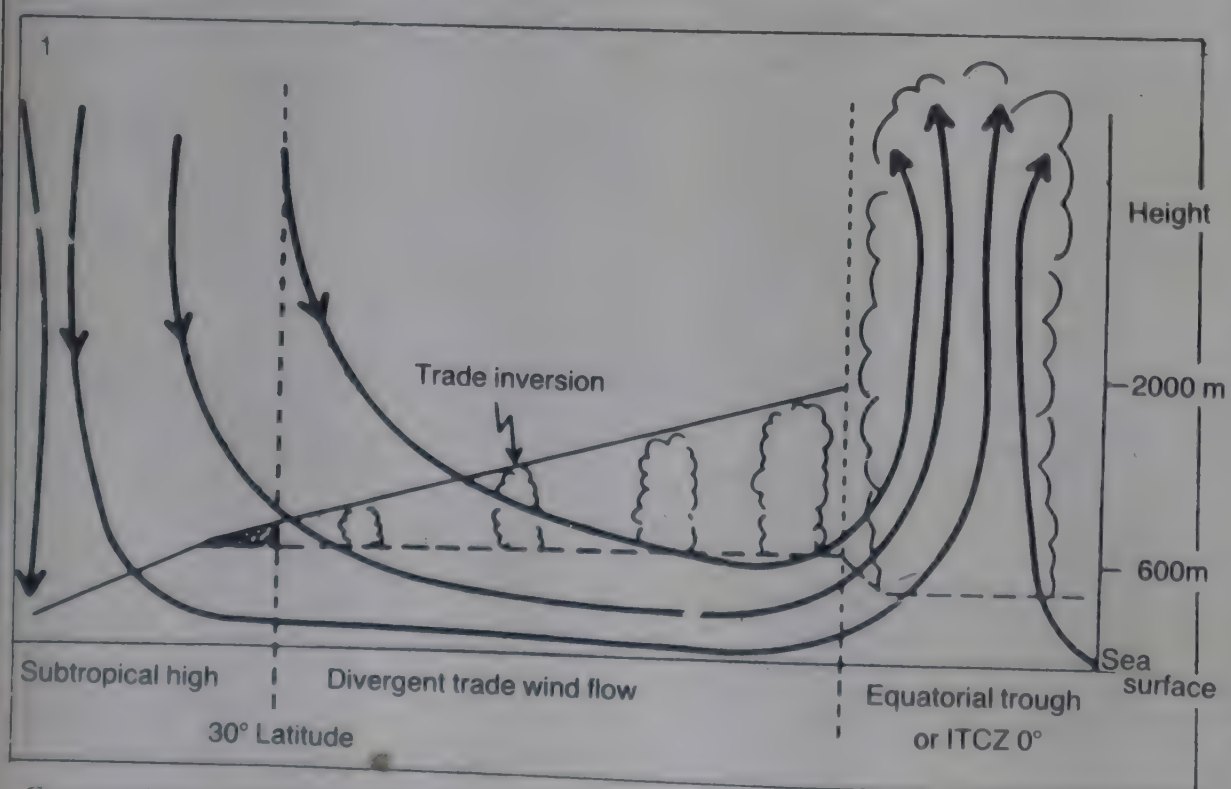
Global circulation, rainfall and climate

RAINFALL IS the end-product of complex dynamical processes occurring in the atmosphere. The energy source for atmospheric circulation is the radiation from the Sun. However, since the atmosphere is almost transparent to this incoming radiation, most of it reaches the surface of Earth where it gets absorbed by the land and ocean, thus warming them up preferentially. Atmospheric circulation is a response to this heating at the lower boundary. Hence it is easy to see that the conditions prevalent (which control their albedo) at the surface of land and ocean are important factors in controlling the circulation. Rainfall naturally depends on the presence of clouds. Clouds are formed when moist air ascends in the atmosphere causing it to cool, resulting in the condensation of moisture. Over the global tropics the ascent occurs in response to the radiative heat source at the lower boundary.

In an annual average, maximum solar radiation is received in the equatorial regions. As a low pressure belt is created over this radiative heat source, air at low levels from both the hemispheres converges to this equatorial trough zone (which is therefore also called the intertropical convergence zone — ITCZ) and rises. On rising, the air cools, water vapour condenses and intense towering clouds are formed over this region of ascent. Most of the rainfall in the tropics occurs in the ITCZ and the cloud band marking the ITCZ is always a prominent feature of the satellite imagery of the tropics. The circulation is completed by the air flowing outward from the ITCZ at the high level and descending in the subtropical high pressure belts around 30° latitude (Fig 1). The downward movement of air in these high-pressure belts prevents cloud formation. All the major deserts are located in these belts. It is important to note that wheras the rainy belt with rising air is located over the radiative source, the sinking occurs over the deserts which are radiative sinks. There are two more cells poleward of the tropical cell (Fig 2a).



Structure of the general circulation pattern showing the mean vertical circulation cells. The strong heating of the surface over the equatorial region gives rise to strong ascending motion of the air over the tropics. This cell also known as the Hadley cell is completed by the descent of the air near 30°N latitudes where the sub-tropical highs are located. Two more cells,one with ascent over the sub-polar lows at 60°N latitudes (known as Ferel cell), and the other a weaker polar cell with descent over the poles,completes the general circulation pattern. The prevailing surface wind directions are also shown



Cross-section in a meridional plane showing the nature of circulation. The strong heat source over the equatorial region causes ascending motion of moist air over the Equator giving rise to intense clouding which is the chief characteristic of the inter tropical convergence zone (ITCZ). Surface flow of air occurs from higher latitudes on both sides of the Equator

Because of the tilt of the Earth's axis, there is a seasonal variation of the declination of the Sun. This implies a seasonal migration of the latitude of maximum heating and, consequently, the location of the ITCZ also exhibits a variation with season. The amplitude of this seasonal oscillation is rather large over the monsoonal regions of the world.

During our summer, the rainbelt associated with the ITCZ moves on to our subcontinent in response to the

also shown to decrease (enhance) the rainfall in several studies. In a simulation experiment involving massive irrigation of large areas in Africa by S Manabe, the maximum rainfall over parts of Africa was found to increase by 100 per cent.

All these experiments show that model-simulated climates are sensitive to land surface boundary conditions. When soil moisture availability or surface albedo are changed regionally to simulate the effects of deforestation, changes occur in the temperature and motion field of the atmosphere over the region which generally result in a decrease of rainfall. These changes are above the levels of the natural variability of the model-simulated climates.

Thus the results of these simulations by and large support the concept of biogeophysical feedbacks which would lead to rapid desertification after an initial deforestation, particularly in marginal areas around the deserts. However, the changes in albedo and soil moisture assumed to represent deforestation in these studies have been generally rather large when compared with what they really are. Thus satellite observations indicate that the albedo changes over Sahel during a drought are only from 20 to 28 per cent whereas in the model studies desertification was taken to be a change in albedo from 14 to 35 per cent. But since other studies with less dramatic changes in albedo have confirmed the nature of the change induced in the rainfall, these observations imply only a reduction in the amplitude of the impact.

Also, the actual conditions do not always deteriorate monotonically. For example, it was found that during a period of several years in which drought conditions prevailed over

radiative sources created there. We owe our monsoons to this annual visit of the ITCZ. The rainfall received is by no means uniform over the entire country. It is large over the Indo-Gangetic plain which is the seat of this rain-giving system in the peak monsoon months of July and August, and decreases westwards towards the Thar desert. It is also large along the west coast and in the hilly areas in the north-east due to the ascent of air forced by the terrain.

Consider next the implications of this circulation for the climate of the tropics. The important climatic elements, namely temperature, pressure and rainfall, exhibit a marked variation with latitude. Hence, we consider first the climatic regimes on an idealised Earth over which there is no variation in the east-west direction (Fig 2b). The mean surface temperature is maxmium in the equatorial regions and decreases poleward. In this annual average picture, the maximum rainfall occurs in the equatorial regions which are under the sway of the ITCZ almost throughout the year. Flanking the wet equatorial region on the side would be the wet and dry tropics which are as warm, but not as wet. These monsoonal regions get rainfall mainly in the summer. Poleward of the wet and dry tropics will be found the semi-arid regions with still less rainfall and then the deserts with hardly any rainfall. Poleward of the deserts are the semi-arid regions of the mid-latitudes and then the humid mid-latitudinal regions and, finally, the polar and subpolar regions. The climatic regimes of the real world are not too different from this idealised picture (Fig 3).

Note that relative to the rest of the tropics we in India are particularly fortunate in getting the monsoon rains up to rather high latitudes. We owe this special privilege to the presence of the massive Tibetan plateau which acts as an elevated heat source and pulls the ITCZ over our country.

The location and extent of these different zones exhibit considerable variability. Over long time-scales we know that the polar-subpolar regions expand and contract as we experience the oscillation between ice ages and warm interglacial periods. Over shorter time-scales, such as a century, the global mean temperature changes and deserts spread and shrink. Once in every three to seven years major events occur such as the El Nino over the Pacific which appear to be also linked to the fluctuations of the monsoon. There are also major variations from year to year in regional as well as global climate.

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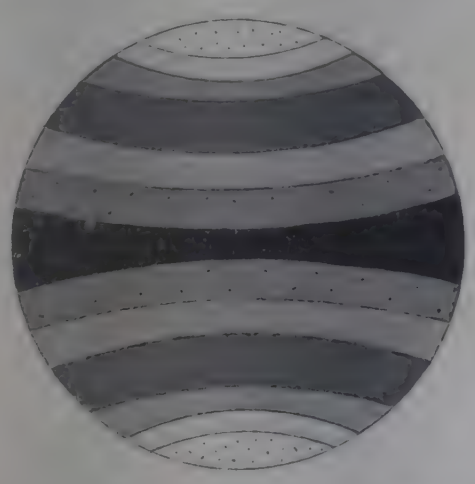
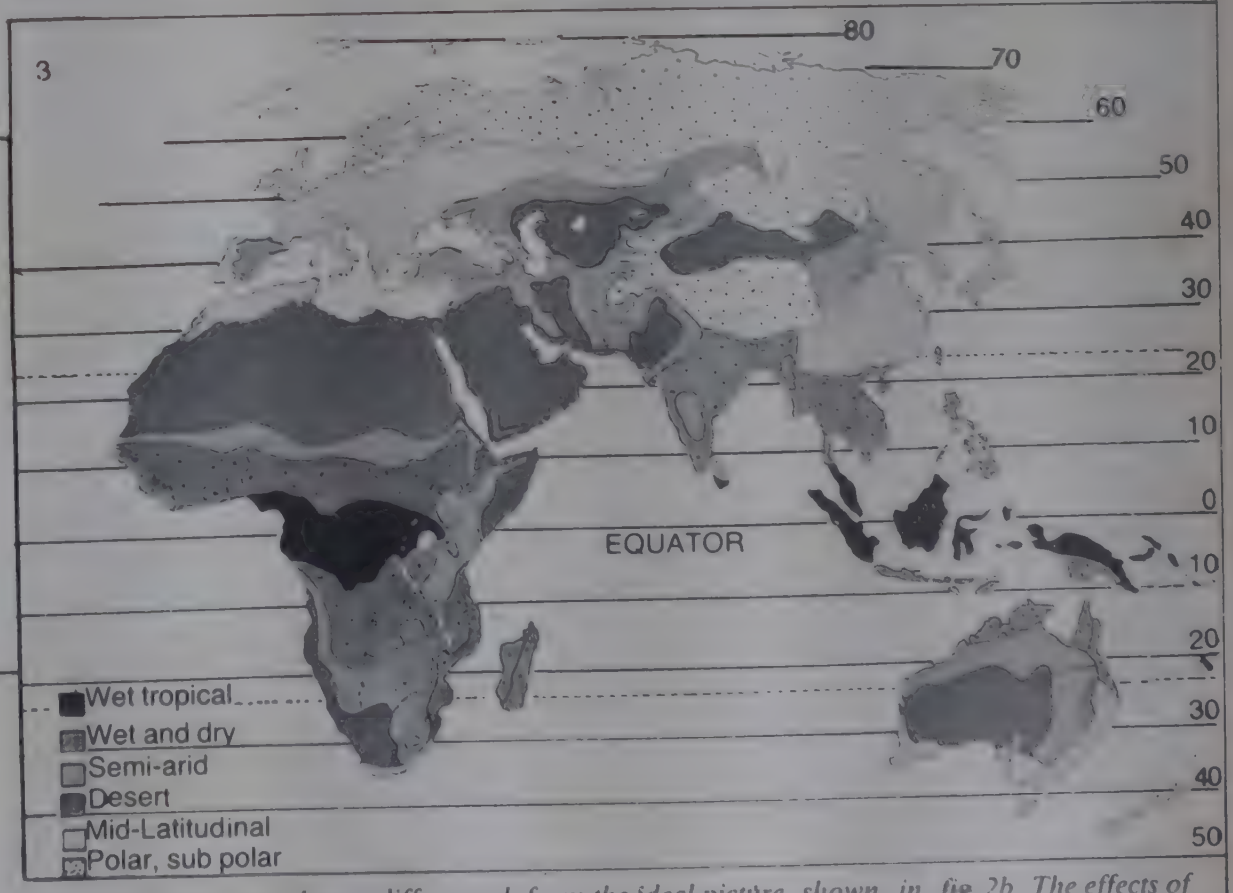
2b



Idealized climate zones based on the general circulation pattern shown over the globe where the east-west variation is ignored. Corresponding to the ascending limbs of the vertical circulation cells are regions enjoying high rainfall, while the regions where the dry air descends the large desert regions are located. In between are the semi-arid regions. The tropical region is divided into the wet tropics and the wet and dry tropics. In the latter, rainfall occurs primarily in summer.

3



Actual climate zones do not differ much from the ideal picture shown in fig 2b. The effects of ocean and other orographic features modify the climates somewhat. In the African continent is seen almost a perfect demarcation of zones. The fortunate situation enjoyed by India can be appreciated by noting the other regions with the same latitudes falling into the semi-arid zone

Sahel, the albedo over certain parts of Sahel in fact decreased after an initial increase. This suggests the presence of other negative feedbacks in the system which would temper the effect of the positive feedbacks in real life. We thus expect perceptible changes in rainfall to occur not within a few years but only over long time-scales of several decades or longer.

Empirical basis

There are practical difficulties in detecting any effect of variation of plant cover on variation of rainfall in real life. The reason for this is that there is a tremendous variation in rainfall both in time and space, which exists regardless of any variation of plant cover. Thus, while allowing for this inherent variation, discerning the variation induced by a man-made change in plant cover presents considerable statistical difficulties. Serious attempts have nevertheless been made to investigate the nature of the influence of forest cover on rainfall on the basis of observations over smaller regions within India.

The first such attempt was the classic work of H F Blanford over a century ago. In the early days of British rule, the government had stopped the practice of "shifting cultivation" over a large tribal belt in Central India. The forest cover over this region had therefore made a recovery around 1875-1885, while the vegetation cover in some other neighbouring regions had remained unaffected. Blanford compared the rainfall series over these two regions to determine whether the recovery of the forest cover had led to an increased rainfall in the region where shifting cultivation had been halted. His conclusion was that there was indeed evidence for an increase in rainfall with the recovery of forest cover.

A second study of the same problem by Meher Homji looks at the other side of the coin. He compares the rainfall over time for a number of stations on the Western Ghats which have suffered varying levels of deforestation. He concludes that the level of reduction in rainfall is correlated with the extent of deforestation. However, results of a subsequent in-depth analysis of the time series does not support this conclusion since no clear trend is discernible.

These results are merely suggestive; they support the expectations based on the effect of the changes in the albedos and the soil moisture. But they are by no means conclusive. This is because these studies could not overcome the inherent statistical hurdles. That is not to say that the statistical problems are insurmountable. We can hope for a definitive answer on this critical question in the years to come.

So the situation, as far as we understand it now, is as follows:
Loss of forest is in theory likely to lead to a decrease in rainfall, although the facts are as yet unclear as to the exact quantitative relation between the two and the time-scales over which they occur. However, loss of forest does decidedly decrease the availability of this water for plant and human use. The vast destruction wrought by rapid forest removal to the long-term economic base of the country including the priceless biological heritage should be a greater deterrent to forest removal than what we now know about possible climatic change. It has been said that forests precede civilisations and deserts follow them. Let us hope that our present civilisation with its much greater scientific awareness of the consequences of its actions will be an exception to this rule.

Interannual variations of the monsoon

ONE OF the most challenging unsolved problems in monsoon meteorology is to understand and predictits variations from year to year. It is believed that these interannual variations arise primarily because the response of the coupled ocean atmosphere system to the solar forcing is rather complex and although the incoming radiation is the same on the same date irrespective of the year, the actual conditions at the surface of the tropical oceans are by no means the same on the same date of each year. Because of the slow response of the oceans, the history of the previous seasons leaves its footprints on these waters, as it were, and gives a slightly different character to every year. Regional variations of the monsoon on the interannual scale can also arise from interaction of the ITCZ over our region and that over the Pacific. During the El Nino, surface temperatures over southern and central Pacific became abnormally high, and the ITCZ over the eastern Pacific moved southwards from its usual location. This results in droughts over some regions, floods over others and a sudden drop in the fish catch off the coast of Peru. Apparently these events are linked to (and probably triggered by) abnormal behaviour of the ITCZ over the Indian region. With the advent of satellites the prospects of our understanding the interannual variations and their teleconnections have become very bright and the future holds considerable promise for their prediction.

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Forests and water balance

HOW DO forests affect the rain once it falls? The forest canopy firstly breaks the fall of the rain as it comes down, then ensures its more gentle penetration in the ground, reduces soil erosion and runoff and improves the underground water table. This regulatory effect of the forest on the water cycle is vital in preventing flash floods and maintaining a continual flow of water into streams and rivers. In the absence of this regulation, our rivers flood in the monsoon and go dry in the summer. Since the water supply in the summer is critical for us, this has the same consequence as a decline in the rainfall. Furthermore, this implies that once vegetation cover is reduced, it becomes more and more difficult to re-establish it, and landing us in a vicious cycle.

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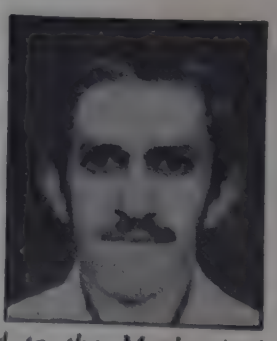


Dr Prasad is a mechanical engineer, who did his undergraduate studies in Bangalore, then MS at Brown University, and PhD at State University of New York, Stony Brook, USA. Presently he is an associate professor at the Indian Institute of Science, Bangalore, affiliated to the Mechanical Engineering Department and also the Centre for Atmospheric Sciences. His main interests are atmospheric radiation, lasers and their applications and renewable energy.

A close encounter with Uranus

EARLY THIS year Voyager 2, the US spacecraft, zeroed in on its third port of call — Uranus, the seventh planet of the solar system. A veteran of outer planets, the eight-year old weather-beaten spacecraft is now headed for Neptune. It will get there in 1989, giving scientists enough time to sift through and unravel the data it beamed back from Uranus before it starts sending in information on Neptune.

Uranus was accidently discovered on 13 March 1781 by an amateur astronomer, William Herschel, while he was scanning the skies for double stars. The diameter of Uranus is four times that of Earth. It's a massive planet no doubt — 14.5 times as massive as Earth — yet when viewed from a distance of nearly three billion kilometres away it's like "observing a pea across a length of five football fields" (about 150m)", so says Lawrence Soderblom, leader of the imaging team. Ground-based findings on Uranus are meagre.

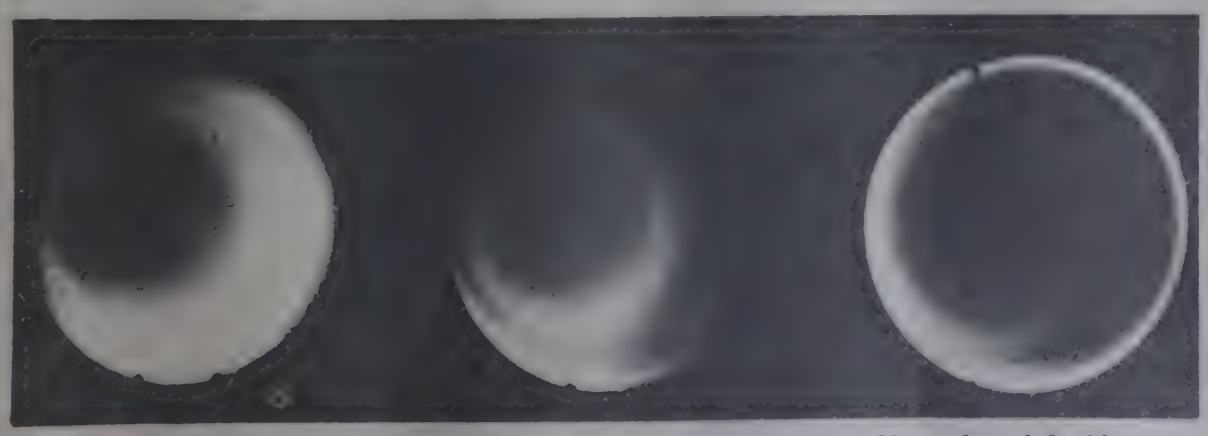
Uranus and its twin, Neptune, are classed with Jupiter and Saturn in the gas giant family. But Uranus is only a mini-giant — Jupiter and Saturn are 318 and 95 times as massive as Earth — and it belongs to a separate subspecies. Its gaseous envelope is very much less than that of the true giants. According to theoretical models starting with the known cosmic abundance, Uranus has three layers : a heavy, rocky central core about the size of Earth; a mantle of water several thousand km thick surrounding the core; and a hydrogen-helium atmosphere extending outwards for several thousand kilometres.

Uranus is a peculiar planet. It rotational axis lies almost in the plane of its orbit, whereas for most other planets the axes of rotation are nearly perpendicular to the orbital plane. As a result of this tilt, each pole is sunlit for half the period of its revolution, that is, 42 years. Right now its south pole is lit up and its axis is pointing towards the Sun. If we could see it now from Earth with its rings, it would look like a bull's-eye. Its satellites circle its equator, which is normal. But what caused the abnormal tilt of the planet's axis we still don't know.

Another strange misalignment was discovered by Voyager. Uranus' magnetic field is tilted by 55 degrees to the axis of rotation; the Earth's is only a 11-degree tilt. Scientists had expected Uranus would have a magnetic field. Its presence was discovered by instruments abroad Voyager five days before the closest approach on 24 January 1986. The spacecraft detected circularly polarized radioemission, suggesting the presence of the field. According to Norman F Ness, principal investigator of magnetic fields, Uranus' magnetic field encompases the entire ring system and the moons. The strength of the field is comparable to that of Saturn and Earth (0.25 gauss) at its equator. (The values for Saturn and Earth are 0.21 and 0.31 gauss.) The abnormal tilt of the magnetic axis places the planet in a category called oblique rotators. So far only neutron stars and pulsars have been known to be oblique rotators.

The oblique rotator status places severe constraints on the internal structure of Uranus. Also because of this peculiar orientation of the magnetic field the magnetotail, which trails on the dark side of the planet, twists like a corkscrew as the planet rotates. These gyrations have helped us determine the length of the Uranian day. It is 17.3 hours.

Abundant impact craters of many sizes pockmark the ancient surface of Titania. The most prominent features are fault valleys that stretch right across the satellite. They are up to 1,500 km long and as much as 75 km wide. The sunward facing walls of the valleys are very bright, partly due to the lighting angle; the brightness also indicates the presence of a lighter material, possibly young frost deposits. An impact crater more than 200 km across lies at the very bottom of the disc; the crater is cut by a younger fault valley more than 100 km wide. An even larger impact crater, perhaps 300 km across, is visible at the top



The sunlit pole.Uranus as seen through the violet, orange and methane filters (from left). Voyager was 2.1 million km from Uranus; the resulution is 300 km. Faint zonal patterns are seen around the pole. The polar region is one of high haze particles that are dark in the violet image. The discrete clouds seen in the centre image and methane image (right) are probably buoyant features of the methane cloud layer that rise to somewhat higher altitudes than the main cloud mass. A high altitude haze brightens the rim of the planet in the photograph on the extreme right.

The presence of magnetism indicates the presence of convective motions within an electrically conducting fluid. Does Uranus have such a conductive fluid? What could the fluid be? According to David Stevenson of Caltech, the Uranian oceans — which probably contain ammonia and methane — are under tremendous pressure from the weight of the atmosphere. This raises the temperature of the oceans to several thousand degrees kelvin. Under such conditions the water and ammonia dissociate and become conductive. According to Stevenson, the ocean "is behaving like molten salt".

A strong ultraviolet emission was detected on the sunlit hemisphere. Similar emissions — but very much less intense — had been detected on Jupiter and Saturn too. The mission scientists have named it electroglow. One distinguishing factor between aurorae and electroglow is that electroglow needs sunlight to set it going. So the phenomenon, which is caused by electron collisions on molecular hydrogen, does not occur on the dark side of the planet. Here Voyager 2 detected an aurora around the magnetic pole. In an elec-

This false-colour Voyager picture of Uranus shows a subtle banding. The picture is a highly processed composite of three images obtained on 14 January 1986, when the spacecraft was 12.9 million km away. The cloud visible here is the most prominent feature seen in a series of Voyager images designed to track atmosphere motions. (The occasional doughnut-shaped features are shadows cast by dust in the camera optics; the processing necessary to bring out the faint features on the planet also brings out these camera blemishes.) In a true-colour image, the cloud would be barely discernible. Uranus appears like a huge aquamarine ball

troglow, energy from the Sun is re-radiated with many times the initial energy. Uranus findings would explain how exactly energy transfers occur in the electroglow phenomenon.

Voyager 2 studied the atmosphere of Uranus by ultraviolet observation of the light of a star as the star passed behind Uranus with respect to the craft. Mission scientists discovered acetylene and deeper down they could detect spectral signatures of other hydrocarbons, probably primarily methane. Outward, the extended atmosphere comprises molecular and atomic hydrogen and lesser amounts of helium. It is the methane that absorbs red light and gives the planet its blue colour. Voyager could detect a patch of brown photochemical smog on the sunlit pole.

The mission scientists looked for clouds and for the banding patterns so obvious on Jupiter and Saturn. The Jovian kind of clouds, if any, are probably deep down in the atmosphere. The banding pattern was very faint and stood out only after image enhancement. The aquamarine surface of Uranus seemed more like an ocean than a gaseous atmosphere. The temperature at the top of the atmosphere is 60°K (− 213.16°C). It is extremely cold.

Atmospheric banding is caused by the upwelling and sinking of hotter and colder gases. The rising gases give rise to a haze and sinking ones cause a darkening. And then as the planet rotates these colours are stretched across the latitudes, creating bands. Could a fully tilted planet like Uranus have such bands? The imbalanced impact of sunlight, it was speculated, would probably prevent band formation. However, the fact that Uranus has bands confirms that rotation, not sunlight, determines the motion.

Four thunderhead-like clouds were seen between latitudes 25 and 50 and from that scientists could tell that the relative wind velocities are of the order of 100 m per second. With a larger sample it would have been easier to track wind patterns on the planet.

It was thought that the temperature of the Sun-facing pole would be slightly higher than that at the equator or at the dark pole. Infrared measurements indicated that temperature is almost constant from equator to pole with a slightly cooler band between 20 and 40 degrees latitudes — probably a result of upwelling. The atmosphere above the dark north pole is somewhat warmer than that at the sunlit pole. What causes the heat to be distributed so evenly is of great interest. The photopolarimeter findings are still being analysed to find out how much heat the planet receives from the Sun and how much it generates on its own. Heat being generated inside the planet also contributes to warming the atmosphere.

Voyager took this image while in the shadow of Uranus, at a distance of 236,000 km from the planet and a resolution of about 33 km. Few particles of the ring are less than one metre in size. All the previously known rings are visible here, and some of the brightest features in the image are bright dust lanes not seen at other angles. The 96-second long exposure and the high phase angle at which Voyager imaged the rings allowed this spectacular observation, acquired through the clear filter of Voyager's wide-angle camera. The long exposure produced a noticeable, non-uniform smear as well as streaks due to trailed stars. An Indian scientist J J Rawal who works with the Nehru Centre had predicted the extra rings and moons for Uranus

Upper left – The complex terrain of Ariel. Voyager captured this view of its southern hemisphere through the green, blue and violet filters of the narrow-angle camera; the resolution is about three km. Most of the visible surface consists of relatively intensely cratered terrain transected by fault scarps and fault-bounded valleys. Some of the largest valleys, which can be seen near the terminator (at right), are partly filled with younger deposits that are less heavily cratered. Bright spots near the limb and toward the left are chiefly the rims of small craters. Most of the brightly rimmed craters are too small to be resolved here, although one about 30 km in diameter can be easily distinguished near the centre. The bright-rim craters, though the youngest features on Ariel, have probably formed over a long span of geological time

Umbreil, the moon with a frost-lined crater on the top perched like a party hat, is remarkable for its drabness and lack of signs of any internal activity

Oberon, the outermost moon, is heavily crated and but for some filling up of craters with dark lava, it shows no signs of any internal activity

The Uranian satellite Miranda from a distance of 147,000 km. This picture was constructed from images taken through the narrow-angle camera's green, violet and ultraviolet filters. It is the best colour view of Miranda returned by Voyager. Its regional geologic provinces show very well in this view of the southern hemisphere, imaged at a resolution of 2.7 km. The dark-and bright-banded region with its curvilinear traces covers about half of the images

In 1977, ground-based observations had shown that Uranus too has rings. Nine were known till Voyager updated the information, adding two more complete rings and a series of about 10 partial rings. The spectacular rings of Saturn are made up of particles of various sizes — micrometer to a few meters across. They are the most outstanding feature of the planet. The Uranian rings comprise of large chunks — none less than a metre across — and they are jet black, "twice as black as soot" an astronomer had remarked. The blackness of the Uranian rings is probably due to the breakdown of methane ice on the surface of ring forming chunks. When bombarded with high energy protons, methane dissociates, letting the hydrogen escape, leaving behind the carbonaceos coat. As to why there are no small sized particles in the rings the speculations are either that they were never formed, or that any that are formed are swept up by the magnetic field of the planet which envelops the rings. It has also been speculated that the rings are the result of a disintegrated moon.

Occultation studies of the rings showed that the outermost (the epsilon) ring which contains the most material, is 25 m thick and 20 to 30 km wide. Its structure varies from the inner periphery to the outer. The exact composition of the ring matter could not be studied because of lack of time. In just a brief six hours, around its closest approach, Voyager had to soak up as much data as it could. The constraint on time was because of the unique orientation of the planet and the need to use its gravitation to catapult Voyager on to Neptune. Voyager discovered 10 new moons of Uranus, ranging in size from 20 to 50 km in diameter. An excellent close-up of only one major moon, Miranda, was possible. However, Voyager did manage to glance at the four other large moons. In their outward order, the major moons are Miranda, Ariel, Umbriel, Titania and Oberon — all drab dull objects, dark and icy.

Geologically, all but one seem to have been surprisingly active. Miranda, an

astronomical patchwork affair, is "a bizarre hybrid of every kind of exotic terrain in the solar system", according to a mission scientist. It has sinuous valleys of Mars, the grooved terrain of Jupiter's moon Ganymede, cratered highlands like Earth's Moon and extremely high sheer scarps. It has 10 different terrain types shaped by tectonic forces. One theory is that Miranda, 480 km across, was probably disrupted by some kind of impact and when it re-fused some of the chunks fused inside out. Craters on Miranda seems to have been filled up by some kind of dark flowing material which has probably come from its interior.

Tectonic activity on the moons seem to decrease with increasing distance from the planet. Here again is an exception to prove the rule. Umbriel, the one between Ariel and Titania, seems remarkably inert. Its surface is dominated by craters and how it escaped the forces that shaped its neighbours is not clear.

Perhaps the same thing that makes rings dark makes the satellites dark — organic matter derived from methane due to radiation exposure. The planet's radiation belts do impinge on all its major moons. But, according to one member of the imaging team, the plausible explanation for dark matter on one Umbriel wears a crazy party hat — a peculiar white ring about 150 km across — at its upper end. This is perhaps frost-lined crater.

Ariel, 1200 km in diameter, is crisscrossed with valleys and scarps. Dark mysterious lava seems to have flooded some valleys, moving in glacier-like fashion.

Titania, 1600 km across, has several arrays of craters. There are also several trenches and scarps and some signs of internal activity.

Oberon, the outermost satellite, is the same size as Titania and except for the signs of dark icy lava it shows no sign of internal activity.

moon in contradicted by data on another. Several mechanisms might be responsible for the mysterious lava.

From the densities calculated for the four major moons — 1.5 to 1.7g per cubic centimetre — they seem to be composed of 50 per cent water ice and 50 per cent rock. That's a higher percentage of rock than in Saturn's moon.

Most of the data about Uranus that Voyager has sent back is new and much of it unexpected. New questions have been raised and it is even likely that new disciplines of planetary science will spring up to try and answer them.

Voyager 2 was designed to perform at peak performance for about five years. At the time of its launching, only encounters with Jupiter and Saturn were on its itenary; the spacecraft surpassed almost all performance expectations even in those encounters and was then set on its path for Uranus. However, engineers had to reprogram Voyager 2 almost entirely for its new task. The extensive reprogramming has made it a "different spacecraft" from what it was.

Uranus is so far from the Sun that the intensity of sunlight there is 1/400 that at Earth.

With such low levels of ambient light, photography needs longer exposure, say 15 to 20 seconds. And when the spacecraft is travelling at a speed of nearly 75,000 kmph this is no easy task. The camera cannot be fixed. A technique called image motion compensation which revolves the spacecraft when the camera shutter is open was used for long exposures. Thus high resolution pictures were possible.

Signals travelling at a speed of light take 2 hrs 45 minutes to reach from Uranus and as a result of the vast distance travelled, they are weak. At Jupiter, Voyager 2 transmitted data at 115,200 bits per second (bps); at Saturn the value fell to 44,800 bps. Under normal circumstances from Uranus it would have been not more than 8000 bps. By a technique called arraying – using two or more antennae to receive the signal – the transmission rate was raised to 21,600 bps. Data compression techniques thus improved transmission rate. Now let's wait for the Neptune encounter.

S V GIRIJA

PEOPLE

B C Roy award

PROF V Ramalingaswamy, director general of Indian Council of Medical Research, Dr R K Menda of Bombay and Dr M M S Siddhu of Lucknow have been selected for the Dr B C Roy national award for 1985.

The awards are of the value of Rs 50,000 each and a silver salver.

Prof Gunnar award

PROF C P Malik, head of the department of Botany, Punjab Agricultural University, has been awarded the prestigious Prof Gunnar Erdtman international award for palynology for his contribution in pollen physiology and biochemistry for 1984.

ICAR award

DR P G Viswanathan Nair, senior scientist of the Central Institute of Fisheries Technology (CIFT) in Cochin, has been awarded the Jawaharlal Nehru award for 1983, for his post-graduate research on cholesterol metabolism.

Dr Akineni Ramesh Babu is the other recipient. His PhD work on "Determinants of research productivity" in the field of agricultural extension has been chosen for the award.

The award is given annually by the Indian Council for Agricultural Research (ICAR) for the best Ph D thesis.

Dr Nair is now working as scientist-in-charge of the Veraval Research Centre of CIFT in Gujarat.

Nayudamma fellowship

Dr G Thyagarajan, director of the Central Leather Research Institute here, is the first recipient of the Nayudamma fellowship instituted by the International Developing Research Centre (IRDC), Canada.

The post-doctoral fellowship is to perpetuate the memory of Dr Y Nayudamma, who made significant contributions to applied science in general and leather research in particular. He was on the IDRC board of governors from 1983 till his death in the "Kanishka" plane crash last year.

R D Birla award

DR RAJA Ramanna, chairman of the Atomic Energy Commission was given the prestigious R D Birla memorial award of the Indian Physics Association for his contributions in physical sciences for 1985-86.

The award is in recognition of his original contributions in the field of nuclear fission studies, pioneering contributions in planning and implementation of nuclear power programmes in India, and in establishing new and vital research centres with allied facilities in this country.

Indian scientist in U S honoured

AN ALUMNUS of the Indian Institute of Technology, Powai, Bombay. Dr Shantikumar V Nair, is one of 100 presidential young investigators of 1986 named by the U S President, Mr Ronald Reagan. The award carries a grant of $100,000 annually for five years.

Thirty-two-year old Dr Nair who passed from the IIT in 1976 did his M S and Ph D from the University of Columbia, New York. He is now a tenured professor in Massachusetts University. His post-doctoral work is in specialized materials for nuclear and space technology.

COSMOS: TESTING GROUND OF THEORIES

HERMANN BONDI

COSMOLOGY, THE subject of the structure and history of the universe, is something that people have thought about for millenia. But we can definitely date the occasion when it became a science — essentially about 160 years ago, though there were precursors to this.

What is science? It's above all a field where you must make theories, pictures of the world that can be tested. The essential thing in science is that a thing you say may be shown to be wrong. If you don't say something that can turn out to be wrong, you haven't contributed. It's like weather forecasting. Only if you say something specific, something that can be proved wrong, can you have said something worthwhile. In science, the essential thing is that these tests are empirical, by experiment or observation. So the question is: can we say anything about the universe that is capable of being disproved by experiment or observation?

The study that made this possible is a question raised by a German astronomer Heinrich Olbers. When he looked at the sky, he found, as do all of us, that the sky is filled with stars, some of which look bright, some medium and others faint. Now *he* thought that on an average stars that are bright look so because they are near us. The medium stars are farther, and the dim ones very far away. This accounts for, both, why there are relatively few bright stars, and why they look so bright. So also for medium and faint stars.

Olbers thought that if one considered the stars in space to go farther and farther, most would be so distant that we couldn't discern them individually but there would be so many of them that there would have to be a background glow from these stars. He then set about calculating this background glow. To do this, to deal with the depths of the universe which one hadn't even seen, he had to make assumptions, which, even today, one would agree were the simplest, and most straightforward.

His first assumption was that,by and large, the universe was uniform. That is to say, even far away, it is much the same as it is in our neighbourhood. There are stars, some closer together, some farther apart. Some are in groups, some alone. Some emit more light, some less. But on an average, the nature of the average star, and their average distance from each other, is the same far away as it is nearby. Olbers already knew that light, although it travels fast, has a finite speed. So, knowing that the universe is uniform doesn't tell you how much light we receive from very distant objects because they must have sent out that light a long time ago for it to arrive here todav.

So his second assumption was that the universe is unchanging, that, a long time ago, things were very much the same as they are today. He thought that these two assumptions implied the next. This we now know is a third assumption, namely that the universe is not in a systematic state of motion. He assumed that there was no major systematic motion and that the universe was static.

Fourth, he assumed that we can apply our knowledge of physics as much far away and long ago as we can today. It would be foolish to try to explore the depths of the universe by first throwing away what knowledge we have. Using these assumptions one can calculate the background light.

The diagram shows ourselves in the centre, surrounded by a shell with radius r and thickness h. h is small compared to r, but the whole is of such an enormous size that there are many stars in the shell. The surface area of the sphere on which the shell is built is

$$4 \pi r^2$$

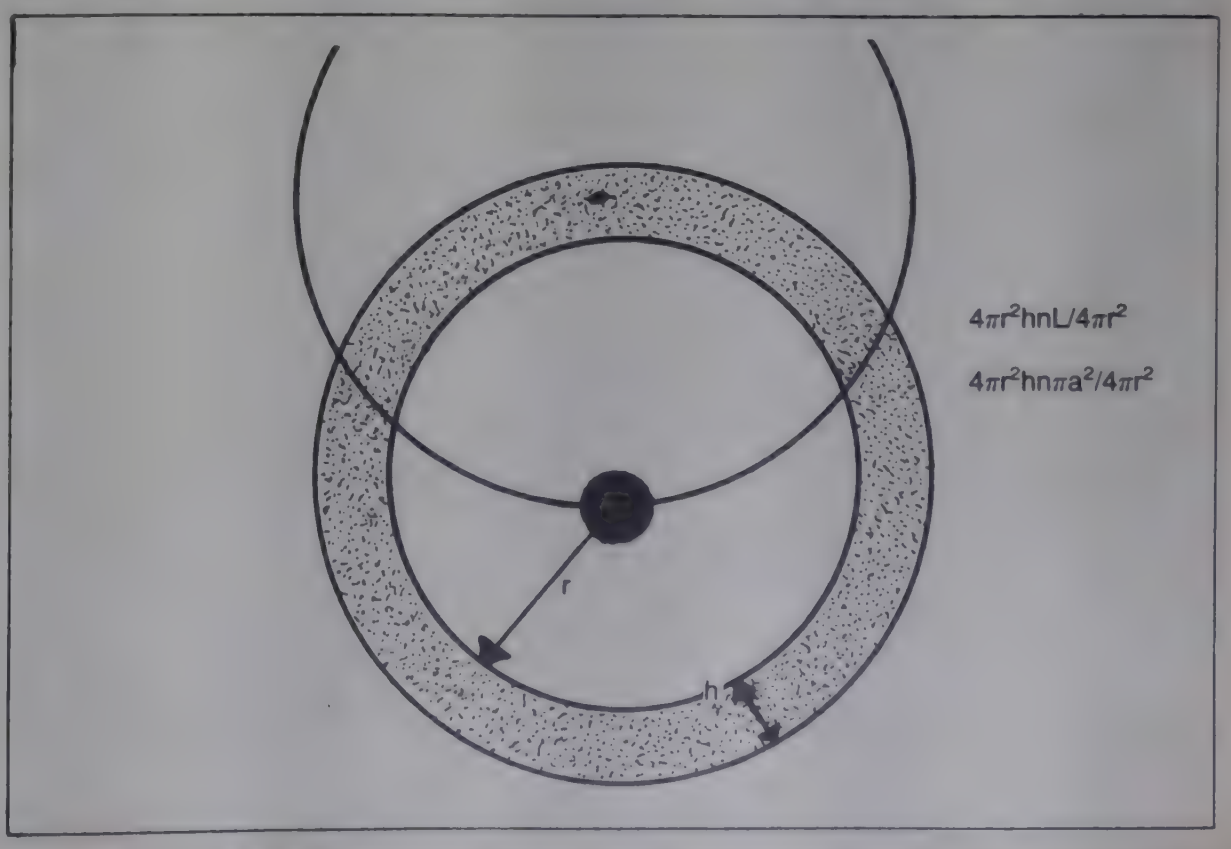
and for a thin shell, the volume is

$$4 \pi r^2 h$$

If the universe is uniform there will be a certain density of stars. This is n. So the number of stars in the shell is

$$4 \pi r^2 hn$$

If an average star sends out light L, then the rate at which all stars in the



shell send out light, is

$$4\pi r^2 hnL$$

How much of that light do we receive? Think of a single star, shown as a bold dot. The light of this star spreads over a sphere with the star in the centre and us on the surface. This sphere has radius r and area $4\pi r^2$. So the intensity of light we receive from this star is the rate at which it sends out light, L, divided by $4\pi r^2$; that is $L/4\pi r^2$.

What is true of one star in the shell is true for them all, so the first expression tells us that the intensity of light received from all the stars in that shell is $4\pi r^2 hnL/4\pi r^2$. Hence, the intensity of light from this shell is hnL. This expression does not contain the radius r of the shell. The larger the shell the more stars there are in it, and the less light we receive from each of them. One just makes up for the other. So, if we think of the next shell outwards or the next one or the one beyond, we receive the same amount of light from each of them. If we add shell after shell after shell, we seem to be getting an infinite amount of background light. This is an uncomfortable conclusion, though fortunately not true. That's because stars have a finite size. Hence they blot out the light of those directly behind. How much shadowing power does this shell have?

If the radius of an average star is a, then the area it presents to us is πa^2. So the area of the stars in the shell presented to us is $4\pi r^2 nh\pi a^2$. The fraction of the sky obscured by stars in the shell is thus $4\pi r^2 hn\pi a^2/4\pi r^2$. Again $4\pi r^2$ cancels out so that each shell obscures the same fraction of the sky.

If the first shell, shall we say, obscures 0.01 fraction of the sky we receive only 0.99 of the light from the next shell, and $(0.99)^2$ of the light from the next shell and so on and we get a geometric series.

If we then try to calculate how much light we get altogether, the term hnL is the amount of light from each shell and must be diminished according to how much of it is obscured by the nearest stars. Now instead of adding shell after shell by geometric series, if each shell obscures 0.01 fraction of light, let's allow for 100 shells, then we have (allowing for a factor of one quarter if properly done) $\frac{1}{4} \times hnL \times 1/hn\pi a^2 = L/4\pi a^2$ for the background light of the sky.

This is independent of the thickness h of the shell. It is also, interestingly, independent of the density n of stars. The more stars there are in a shell the more light we get from that shell, but also, more light is obscured by these stars. And so the expression gives us the intensity of the background as the light L sent out by an average star divided by the surface area of the star. So, we have the intensity on the surface of an average star. The background light of the sky should be equal to the intensity of light on an average star.

The Sun is an average star. We are located 200 solar radii from the Sun. The background light from the night sky should then be $200^2 = 40{,}000$ times broad daylight. But this is not what we observe. We observe that it's dark at night. So, by the observation that this is so we have disproved the theory enshrined in the four assumptions, namely, that the universe is uniform, unchanging, static, and that our knowledge can be used. So they cannot apply to our universe.

And we have disproved this theory

How bright are the stars?

OUR SUN radiates energy at a rate of 4×10^{33} erg per second, that is, with a power of four hundred billion billion megawatts. Its surface temperature is approximately 5800 on the absolute scale (corresponding to about 5527°C). The Sun is by no means the brightest or hottest star in the sky.

In the argument used by Olbers, if we take into account the blockage of radiation from more distant sources by the nearer ones, then taking the Sun as the typical source we arrive at a sky temperature of the order of 5500°C — that comparable to the surface temperature of the Sun. Although this answer is finite, it is obviously abnormally high. We do not see the sky everywhere as bright as the solar disc.

J V NARLIKAR

Professor Narlikar is senior professor with the Theoretical Astrophysics Group, TIFR, Bombay.

Expansion of the universe

IN 1929 Edwin Hubble found an empirical relationship between the apparent brightness of a typical galaxy and its redshift — a relationship that is now known as Hubble's law.

The apparent brightness of an astronomical object is a measure of how bright the object looks when seen from here on the Earth. Naturally, the farther the distance from which we view the object, the less bright it will look. So, if two similar galaxies A and B are such that A is located farther away than B, then A would appear to us fainter than B. Thus, provided galaxies are all equally powerful radiators of light, a fainter galaxy would be farther away from us.

What is the redshift? If the spectrum of an astronomical object is examined, there are spectral lines — bright as well as dark — seen at various wavelengths, spread across it. The bright lines are due to radiating atoms while the dark ones are caused by absorption of light by cool atoms *en route*. Atomic physics enables the astronomer to identify the atoms responsible by knowing the wavelength of these lines. What Hubble found, however, was that the wavelengths of the dark (absorption) lines in the spectra of the galaxies seemed to have increased systematically by the same fraction. That is, all the lines in a typical spectrum were shifted to the longer wavelength end — the end occupied by the red colour of the rainbow. This fractional shift towards the red is called the redshift. Thus, if a line with the expected wavelength of 5000 ångströms Å(10^8 Å = 1 cm) is found to have a wavelength of 5500 Å, the redshift is (5500-5000) ÷ 5000 = 0.1.

Hubble's law tells us that the redshift increases with the faintness of a galaxy. Since the fainter a galaxy the farther away it is, the implication is that the redshift increases with distance. More specifically, the redshift is proportional to distance.

A naive interpretation of the redshift comes from the Doppler effect, that is, the observed increase in the wavelength of light when the light source is receding from the observer. Are we then in a special position in the universe so that all other galaxies are receding from us?

A satisfactory interpretation of Hubble's law that does not confer any special status on us as observers came from Einstein's general relativity. Even before Hubble's result became known, Alexander Friedman had, in 1922, constructed models of the largescale structure of the universe from Einstein's equations, models that implied a systematic largescale expansion of the universe. These models required the universe at large to be homogenous and isotropic. That is, no observers nor any directions have any special status. The Hubble effect would be seen from any part of the universe.

JVN

by the observation that the sky is dark at night. It is for this reason that cosmology is a science. *We have just disproved a theory by observation.*

Now nobody likes to disregard the first assumption or the fourth for if we do that, we may as well write science fiction instead of doing science. Let us examine the other assumptions.

If the universe is not unchanging, how would this save us from extreme brightness, 40,000 times that of sunlight? The light of the distant stars left a long time ago to get here now. So, if a long time ago the stars didn't shine then we wouldn't be getting any light from the distant shells, because there hasn't been enough time for it to get here since the stars began to shine. If the universe is young, so that the stars were switched on only recently, then we wouldn't have a very bright night sky. Abandoning the second assumption leads to a situation that fits the observation that it's dark at night.

Hale Observatories

Galaxies of the two different kinds: elliptical (NGC 147) above and spiral (NGC 6946) below

The other assumption in question is that the universe is static. Now, is it possible to have a universe that is uniform but not static? Is it possible to have a universe that is uniform but yet in motion? That is a mathematical question.

The important point is (something Galileo had already discovered) that velocity is purely relative. You don't have an absolute velocity. You can only speak of the velocity of an object relative to another. And then there is a way of motion that does not upset the continuing uniformity of the system, namely, one where the relative velocity of any two objects is along the line joining them and proportional to their distance apart. Either all velocities are towards the objects receding from each other, or all are inwards, the objects approaching each other.

Consider one dimension. Suppose we have a long line of spacecraft. Any two are, say 100,000 km apart. Suppose you are on one of them and suppose the nearest ones move away at 1 km/sec. And the next ones at 2 km/sec and the next at 3 km/sec, and so on. Every gap here is growing at 1 km/sec. From any of these craft, the nearest neighbours recede away at 1 km/sec, the next at 2 km/sec and so on. We get the same picture from any spacecraft. So here is a system that is uniform and in motion. This system is easily extended to three dimensions. The question is how does this deal with the problem and the assumptions?

We now turn to the physicists. They tell us that if a source recedes from us we see its light shifted to the red side (the frequencies are lower) and the intensity of light we receive from it is diminished. The higher the velocity the greater the effect. If the system is in recession that is fast enough, we will receive much less light from distant shells. The farther a shell, the faster it moves away and the less light we receive from it. If the system were contracting we would get even more light than we calculated earlier.

So, the upshot of this consideration is that one way of avoiding a bright night sky while keeping the first and fourth assumptions, is that the system is young, or that it is in a motion of recession with velocity proportional to distance, or that both statements apply.

Our friends the astronomers tell us that stars don't go on and on. Our nearby stars fill a group called our

Left to right, Thomas Gold, Fred Hoyle and Hermann Bondi – proponents of the steady-state theory of the universe

galaxy. It is a system with 100 billion stars 100,000 light years across. There are several millions of such galaxies. They seem to be distributed equally in all directions on an average. Thus Olbers' arguments should be applied to galaxies rather than to stars, but this makes no real difference. (They also seem to be uniformly distributed in depth. If one analyzes light from these galaxies, one finds a redshift.)

The fainter the galaxy looks, the greater the redshift. If, in the only plausible way, the redshift is interpreted as due to a velocity of recession, and the faintness as due to distance, then the velocity turns out to be proportional to distance. Thus the universe appears to be in the unique state of motion that is allowed by the assumption of uniformity.

Thus we can say that there is good support for Olbers' first assumption (uniformity). There is no need whatever to abandon the fourth assumption (our knowledge applies). But the third assumption (no systematic motion) is wrong. This leaves open the question of whether the second assumption (an unchanging universe) applies or not.

Nearly 40 years ago Thomas Gold, Fred Hoyle and I proposed that the universe was unchanging, that is, in a steady state. This proved to be a fruitful assumption in that it stimulated the brilliant work by Hoyle, Fowler and the Burbidges that showed that in our present universe the heavy elements are synthesized from the most primitive and common material, hydrogen, in just the right proportions.

In those days there was no evidence whatever that the universe had ever been in a different state from what it is now. However, in more recent years new observations have produced such evidence.

If the universe were in a steady state, there should be a definite relation between the amount of starlight present, and the amount of helium since the source of light of the stars is the conversion of hydrogen into helium. It now appears that there is more than this amount of helium about, strongly suggesting that long ago the universe was denser and brighter than it is today, as suggested by the big bang theory, and contrary to the steady state theory.

Moreover, in the late 1960s, Arno Penzias and Robert Wilson discovered a uniform microwave background radiation, a phenomenon best explained as being the very much redshifted radiation remaining from a much brighter, denser early state of the universe.

Thus today the leading theory of our universe is that it is indeed uniform but changing, and that it is in a state of motion of recession with velocity proportional to distance.

Bell Laboratories

Arno Penzias (right) and Robert Wilson, co-discoverers of the existence of a faint electromagnetic radiation that appears to permeate the entire universe. Their discovery lends strong support to the theory that the universe originated in a cosmic explosion several billion years ago

Professor Sir Hermann Bondi is the master of Churchill College, Cambridge and professor of Mathematics at King's College, University of London. He is known internationally for his work in cosmology, gravitation, relativity and astrophysics.

On a visit to India recently Sir Hermann gave a lecture on cosmology under the auspices of the Nehru Centre and the British Deputy High Commission, British Council Division.

PANORAMA

Laser patent dispute

INVENTOR GORDON Gould won a victory over the Patent and Trademark Office (PTO) in the US Court of Appeals on 19 December last year, 26 years after he first applied for a patent in April 1959. His original filing was split into many pieces, the gas-discharge part being one of the major cases still active.

The other two deal with optically pumped lasers and industrial applications. Both have been in and out of the courts for years.

Judge Thomas Flannery wrote that he was "throughly convinced that the PTO made several material errors" in denying Gould a patent on the gas discharge laser. In his final judgement he ordered the government to stop delaying and issue a patent forthwith.

If Gould does win a patent and enforces it, he may collect royalties on the helium-neon laser and the CO laser, a market said to be worth several hundred million dollars. Automated supermarket check-out counters, for example, use helium-neon lasers. Gould sold shares of his laser claim to other investors — including his lawyers — to finance his marathon quarrel with the PTO.

Despite Gould's legal success, many other inventors disparage his claims. William Bennett of Yale, co-inventor in 1960 of the first working gas-discharge laser (a helium-neon device) says it is "ridiculous" that Gould should be recognized as the inventor of the helium-neon laser. Bennett describes Gould as a "clever guy" who pursued his legal claims assidiously.

Degradable material mends bones

A NEW bone material has been developed at the Queen Mary College, London. A natural byproduct of bacterial metabolism, it can be used to mend broken bones. The material is a natural polyester – polyhydroxybutyrate – which can be broken down by enzymes in the human body. The polyester is mixed with hydroxyapatite, a calcium substance which occurs in teeth and bone, and used to hold broken bones together. The exact nature of the mixture has not been revealed, as a patent on the material is still pending.

Presently steel supports are used to hold broken bones together. These actually discourage bone growth. Bone replacement is stimulated by stress; steel supports remove all the load from the bone and also causes a loss of bone mass around the anchored site. The ultimate outcome of all these is a slowing down of the rate of repair. Also, a second operation is often needed to remove the supports.

The new material when used to support broken bones would degrade gradually losing strength and allowing stress on the bone to increase slowly. Besides, the need for a second operation does not arise.

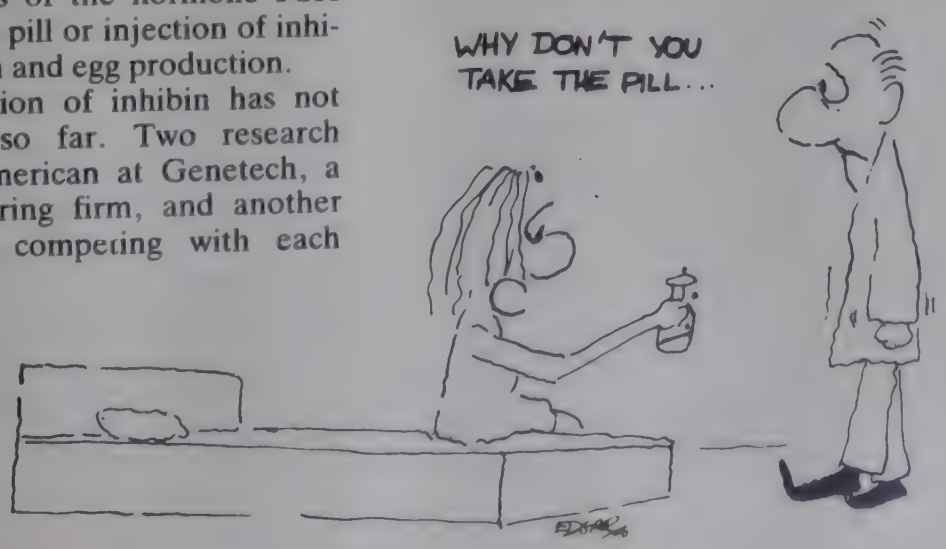
Unisex contraceptive pill

A NOVEL unisex contraceptive pill that blocks sperm and egg production without interfering with a persons libido can now be produced from a natural occurring substance in the body.

The new contraceptive is the hormone inhibin, and it has been talked about for quite some time. This hormone, occurs in the body naturally in trace amounts. It is produced in the testes and also the ovaries. Inhibin acts on the pituitary gland in the brain to regulate the production of another hormone called follicle stimulating hormone (FSH), which controls both egg and sperm production. Increasing levels of the hormone FSH through either a pill or injection of inhibin, blocks sperm and egg production.

Mass production of inhibin has not been possible so far. Two research groups, one American at Genetech, a genetic engineering firm, and another Australian are, competing with each other on the production of the pill. Last December both groups announced that they had cloned cow and pig inhibin. But the Australian group have won the race to clone the human form of the hormone.

Interestingly, the same hormone could also be used to design a vaccine to increase animal fertility. By producing a vaccine against the animal's own inhibin, it is possible to overcome infertile periods in animals and accelerate the onset of sexual maturity.



Largest gravitational lens ever detected

ASTRONOMERS HAVE detected the influence of an unexpectedly large gravitational lens that is 400 times more massive than any other observed lens.

A gravitational lens effect results when light from a distant object is bent as it passes near a strong gravitational field. The bent light paths passing on different sides of the lensing object reach the observer from slightly different directions. Result: one sees several images of the single distant object.

A puzzling aspect of the newly discovered lens is that the astronomers are unable to detect the gravity source either with optical or radio telescopes.

The separation of the two images the astronomers detect is 157 arc seconds compared with only seven arc seconds for the previous largest separation of images. An arc second is one 3,600th of a degree. A separation of 157 arc seconds is comparable to the angle presented by a 25 paise coin at a distance of 25 metres.

The gravitational lens phenomenon was predicted by Einstein in 1936; the first one was discovered in 1979 (SCIENCE AGE, April 1984, p 17). Since

then, eight others have been reported, including this latest one seen by a team headed by Edwin L Turner of Princeton University, USA.

What the astronomers observed were two images of a quasar with identical spectra or colours and redshifts — speeds of recession. The quasar, or quasi-stellar object, from which the light originated is about five billion light years from Earth in the direction of the constellation Leo.

The astronomers used the Mayall optical telescope at Kitt Peak National Observatory in Arizona and the Very Large Array, a grouping of 27 antennas in New Mexico that is part of the National Radio Astronomy Observatory. Both facilities are funded by the National Science Foundation. The researchers first detected the new gravitational lens on 4 March, 1986.

Three possible explanations of the mysterious gravitational lens have been put forth. It could be a giant cluster of galaxies, a gigantic black hole with a mass 1,000 trillion times that of the Sun, or a cosmic string – a theoretical object that might be left over from the early universe.

Stage stress

STAGE ACTING can be as stressful as piloting a plane during critical stages of flight.

Helger Weisweiler of the Institute of Theatre Studies, University of Munich, FRG, studied the pulse rates of actors during performances.At crucial moments – such as monologues – they were found to reach 175 or more and began to slow only when the actor left the stage. Values that high had previously been observed only for test pilots during take off and landing. The high values were also reflected in the stress-hormone content of urine.

How to carry a heavy bag

HUG IT. Heavy bags carried by the handle cause more strain to the back than when supported against the body.

According to a survey carried out by the Osteopathic Association of Great Britain, the British shopping bag with handles causes more strain than the American rigid paper bag held close to the waist.

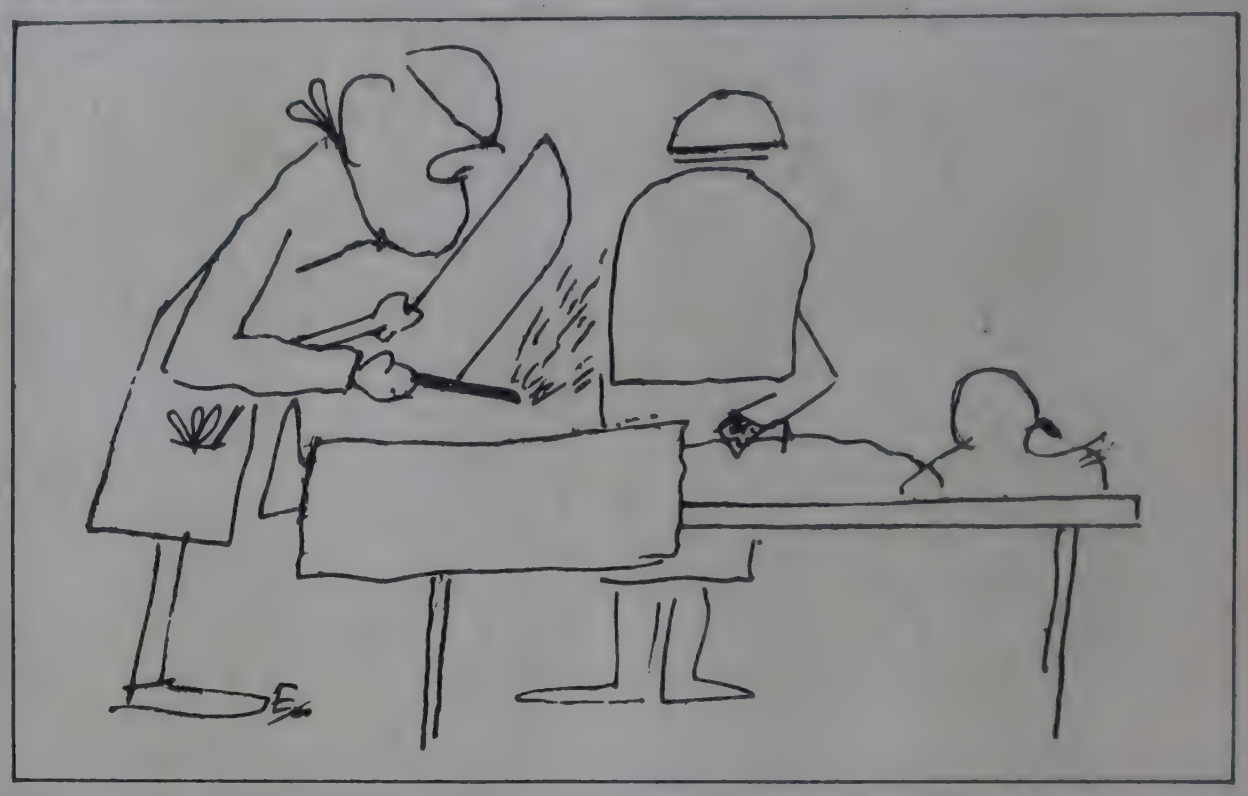
The strain on the back muscles was measured by an electromyograph. Electrodes in the small of the back and across the back of the neck registered the imbalance, if any, between muscles in the left and right side of the body. The greater the imbalance the more the stress. However, this stress could be minimized by splitting the load equally between two bags held in each hand.

Why stitch when you can weld?

WELDING SKIN wounds with lasers proves to be as good as suturing. Besides, the laser welding technique has clear advantages over conventional suturing techniques according to R Patrick Abergel of Harbor, UCLA Medical Center in Torrance, California. The method is sterile; since no touching is involved no foreign materials can get into the wound and, therefore, there is less scarring.

The technique has been tried out on pigs whose skin has a lot in common with human skin. Using too much energy burns the wound and too little does not seal it well; the wound reopens. The trick is to determine the optimum value.

So far, lasers are used primarily for cutting through tissues or sealing off blood vessels. What makes a laser-sealed wound stick together? We don't have a definite answer. Maybe denaturation of the connective tissue is one of the reasons.



Cloning of the guayule

DR DAVID N Radin, a plant cell geneticist at the University of California at Irvine, USA, has developed a new cloning procedure specifically for guayule. The project was funded by the Molecular Biosciences Division of the National Science Foundation.

The guayule, known formally as *Parthenium argentatum* is an extremely drought-resistant plant with an extensive root system used to gather what little moisture there is in the soil. The plant grows naturally in the harsh dry climate of southwest Texas and northern Mexico. It stands between 60 to 90 cm tall, its silvery leaves giving it an ornamental appearance. The plant, a member of the sunflower family, is known familiarly as guayule, after the Aztec word for the gumball plant. The shrub has been of interest for years as a potential new source of natural rubber because its product is almost identical to that from tropical rubber trees.

The cloning technique developed at Irvine uses small pieces of living tissue from intact mature guayule plants to start the growth of tissue cultures in test tubes. Once established, these cultures begin to produce small shoots that subsequently can be removed from the original culture and transferred to another culture medium that induces root growth. The completed plantlets can then be removed from the test tubes and grown in soil, just like normal seedlings.

Radin said an important aspect of his work is the demonstration that guayule can be cloned starting from mature plants.

The new procedure has the potential to produce a major breakthrough in breeding research leading to guayule commercialization.

The next step in his research is to produce larger populations of cloned plantlets for planting and testing in the field.

VDT and eyestrain

EYESTRAIN, HEADACHES and other ill effects of working at a video display terminal aren't eased by changing either the office lighting or the colour of the characters. So say researchers at the University of California, Berkeley, who studied 35 people as they worked at VDT s with white, green, or amber characters in rooms with incandescent or flourescent light. A likelier cause of strain, they found, was sitting too close to the screen or making it too bright.

Effect of marriage on immunity

BESIDES THE psychological effects of being in an unhappy marriage a wrong partner can also have a harmful effect on your immune system.

According to a recent study conducted by psychologist Janice Kiecolt-Glaser, from Ohio State University, USA, divorce leads to increased mortality from pneumonia and tuberculosis in both sexes. A study of a group of women who had been recently separated or divorced found that increased mortality did not result from simple self-neglect following bereavement but there was a definite organic cause — a disturbance of the immune system. The number of natural killers and other immunologically active cells were reduced. White cells that normally produce antibodies showed a reduced response, and herpes activity was increased as compared to a matched group of married women. The shorter the time of separation and the greater the women's fondness for her (ex-)husband, the greater the disturbance in her immune system.

It seems, therefore that not only are the mechanisms of immunity sensitive to stress, but also that social support might act as a buffer, somehow conferring immune protection. Adequate social support does not mean simply having a man — any man — in your life. Living with the wrong partner produces its own immunological problems.

Most people do get over bereavement or divorce in time, but if you are stuck with a partner you don't want, you are probably stuck with the problems of reduced immunity.

Baldness and virility

THE CONVENTIONAL belief that baldness is a sign of virility caused by an excess of testosterone has now been disproved. Balding is actually the result of an increased ability to use testosterone and not an increase in testosterone per se.

Baldness can be blamed on the oil producing glands, sebaceous glands, which are adjacent to hair follicles and produce a protective coating for the skin and scalp. They are found to be physiologically different in bald men.

Researchers at the University of Miami, USA, have compared sebaceous glands in scalp samples removed from 12 balding men with those from hairy scalps. They found that sebaceous glands from bald men had twice the number of testosterone receptors, and double the enzyme level involved in testosterone metabolism in comparison to their non-bald counterparts.

The discovery does not suggest a treatment; that would require an understanding of what is happening at the genetic level.

Two-in-one vaccine

TWO TEAMS of researchers in the US, one from the National Institutes of Health and another from Oncogen, have inserted the *env* gene, which codes for a highly antigenic envelop protein (gp 120) of the AIDS virus, into the smallpox virus, the vaccina virus. The gp 120 protein induces the immune system to produce large amounts of antibodies to attack the AIDS virus, without the person developing the disease himself.

So far, results with mice and rhesus monkey's are very encouraging. Besides, the vaccina virus which forms the basis of the smallpox vaccine would also prevent smallpox.

The chief advantage of using the vaccina virus as a carrier for the gene is purity. Researchers found the protein produced by the *env* gene to be fully mature and unadulterated by other proteins of the AIDS virus or live AIDS virus. The other advantage of vaccina is that it is relatively safe as the basis of a vaccine.

However, neither teams are as yet claiming the altered vaccina as a vaccine for AIDS. The critical proof of its value as a true vaccine would be its ability to destroy the AIDS virus in humans.

However, further experiments under natural conditions would fully investigate the inheritance of the newly acquired defence mechanism.

This technique would benefit Third World countries which cannot afford expensive insecticides. Besides, it could help in the design of new types of toxins against agricultural pests.

Plastics threatens marine life

PLASTICS ARE as great a source of mortality among marine mammals as are oil spills, heavy metals or other toxic materials. They account for over one-half of the man-made products on the ocean surface. According to the National Academy of Sciences, at least 6.6 million tons of trash are dumped overboard by merchant ships each year, some 639,000 plastic containers and bags are tossed into the oceans every day and about 150,000 tons of plastic fishing gear are lost or discarded at sea, every year. Boaters and beach goers add to the marine litter with six-pack yokes (can carriers), picnic utensils, sandwich bags and styrofoam cups. Cities and industries dumping waste directly into the sea are also to blame. The most widespread form of plastic trash are the tiny polyethylene pellets used in the manufacture of plastic items.

The marine life affected particularly are seals, sea lions, turtles and sea birds. According to David Larst of the Marine Mammal Commission, fishing nets have fatal effects on young seals that get entangled in them. They either become exhausted from fighting it or their ability to catch food is restricted.

Smaller plastic items are frequently mistaken for prey by turtles and birds, often with fatal results. Leatherback turtles which feed on jelly fish mistake plastic bags for their prey. Any kind of filmy or semi-transluscent material underwater appears to look like jelly fish to them. When swallowed, these block their digestive tract. At least 42 species of sea birds are known to snack on plastic. Of 50 albatrosses found ill or dead on the Midway Islands,45 had eaten some form of the substance. The plastic had either blocked their digestive tract or caused ulcers. According to programme manager James Coe, of the Marine Entanglement Research Program at the National Marine Fisheries Service in Seattle, the birds were found to have ingested all sorts of plastic. Even sea gulls are not immune to the threat. They have been strangled by six-pack yokes.

Efforts to reduce the amount of plastic dumped in the oceans have been largely unsuccessful. Although the US and 59 other nations agreed in 1972 to outlaw the dumping of durable plastics, among other substances, into the oceans, the treaty failed to address the discharge of ordinary garbage which contains large quantities of plastic items.

A jelly fish: not very different from a plastic bag

Archaeopteryx is not a hoax

ARCHAEOPTERYX lithographica, the oldest species of fossil bird was discovered in 1861 in a Bavarian limestone quarry that yielded five other fossil birds of the same species.

The fossil might be regarded as the most important zoological species known. It is a prime example of evolution. It represents a species in transition between reptiles and birds. Imprints on two pieces of a stone slab that formed a mould around the fossil outline a creature essentially reptilian with avian characters. Like a reptile it has teeth, a long bony tail, abdominal ribs, and three digits on each hand; but it also shows certain bird like characters, notably a furcula (wish bone) representing the fused clavicles, a retroverted pubis and a perching foot. The characters correlate well with a distinct impression of feathers around the forelimb and tail. The authencity of *Archaeopteryx* has become controversial. In 1985 critics based at the University College of Cardiff, Wales, claimed that a limestone paste was probably used to create the image of feathers around a genuine reptilian skeleton.

But according to Alan J Charig and his colleagues at the British Museum in London, recent ultraviolet and microscopic photographs show that, contrary to allegations, the animal's feathers could not be pressed by a forger. The matching hairline cracks and dendrites on the feathered areas of the opposing slabs, show the absence of the artificial cement layer into which modern feathers could have been pressed by a forger. It would be impossible, say researchers, to forge exactly matching crack patterns.

Pure water through ice

DESALINATION OF sea water has been an age-old problem. Energy required by commercial desalination plants makes such a project extremely expensive.

A new process devised by Ted Taylor of Long Island, USA, works on the principle of freeze desalination — A simple low-energy process based on the fact that as water freezes contaminants are automatically excluded from the crystal structure.

A demonstration project in Greenport, Long Island, has been underway for two years.

On cold days (29°F or less), salt water is pumped from the ocean and sprayed onto a plastic-lined holding area. About 10 per cent of the spray freezes. Salt and other impurities are not carried into the crystal structure, the resulting porous bed consists of pure ice. The remaining liquid brine percolates through the ice pack and returns to the sea. The ice pack continues to grow until warmer weather arrives, at which time the melting ice become fresh water. The water's salt content drops to 500 ppm — safe for drinking — after only 10 per cent of the ice has melted. Further melting lowers the concentration to 10 ppm, the original salt content of ordinary sea water being 30000 ppm.

While the process is aimed primarily at desalination, Taylor claims it may be applicable to wastewater treatment as well.

Easier motoring for the handicapped

A NEW aid for handicapped motorists was put on show at "REHA' 86", an exhibition in the southwest German city of Karlsruhe. Using a new hydraulic steering system — "linear level steering" — it makes it easier for the physically disabled to control their special cars.

Levers are arranged so that they can be moved forward, backward or to the sides, with either shoulders or feet, depending on the type of debility. This technical innovation will help make life more comfortable for the disabled.

Pack plane

STUDENTS OF the Leningrad Institute of Aviation Instruments, packed their aircraft and loaded it into an ordinary passenger train. This mini-aircraft is capable of performing different tasks. Its pilot controls it from the ground.

The unusual vehicle attracted experts in environmental protection. Indeed, why should one waste hundreds of litres of gas to patrol the woods in a conventional aircraft when it can successfully be replaced by a "mini-type" with automatic radio bearing? Isn't it also dangerous for human pilots to fly over the crater of an erupting volcano to take air samples or over an industrial enterprise to test its waste level?

The mini-aircraft will be invaluable in biosphere preserves which are usually situated at altitudes several kilometres above sea level, where runways are too short and not too well equipped for conventional aircraft. It will make it possible to tackle many tasks of ecological monitoring at different angles.

Chemists learn from nature

SOVIET SCIENTISTS have synthesized a new specificaction pest control chemical which is capable of protecting a wide range of crops against the most dangerous pests. The chemical, which got the name of "Permetrin", was first produced from the leaves of an ox-eye daisy, when the scientists had established that it was effective even against the Colorado potato beetles, Chloridea cotton moths and gypsy moths.

It takes 15 to 80g of this strong chemical to treat one hectare of farmland. It is ecologically safe and is absolutely harmless for man, cattle and useful insects, such as bees.

Left: A pilot potato farm for testing the efficiency of the new chemical. Each polyethylence dome houses a different potato variety and pest species. Right: A laboratory worker experiments with the chemical to specify a lethal doze for pests

Pest resistant plants

A BELGIAN team of geneticists have successfully protected tobacco plants from insect predators by transferring a bacterial gene that produces an insect toxin into the plant. This is the first practical demonstration of the beneficial application of genetic engineering to make plants resistant to insects and pests. Besides, the trait of insect resistance is passed on to future generations.

Experiments carried out in the laboratory and in the greenhouse have found that larvae feeding on the genetically altered plants become paralyzed after 48 hours and die within three days. The levels of toxin produced in the plant were comparable to that produced in the bacterium.

The altered variety (right) fares better

Early detection of Alzheimer's disease

ALZHEIMER'S DISEASE is a neurodegenerative disorder characterized clinically by progressive loss of intellect. Nerve cells in the brains of patients with Alzheimer's disease contain large amounts of a protein, Alz-50, that does not appear in normal brains.

A monoclonal antibody, specific to this protein has been prepared by immunizing mice against pooled homogenates of brain tissue from patients with Alzheimer's disease.

According to researchers at the Albert Einstein College of Medicine, New York, this antibody can be used to identify the protein in brain slices from normal and diseased human brains. The antibody showed little or no reactivity with normal brains or with regions of the Alzheimer's brain not involved in the disease.

It reacted best with tissue from the diseased temporal cortex, a portion of the brain that develops lesions (tangles and plaques) as neuronal degeneration progresses and intellectual functions are lost in Alzheimer's disease.

However, the function and identity of the proteins that are recognized by Alz-50 are not yet known.

The dawn of the ceramic engine

BY THE year 2020, scientists expect to have perfected an all-ceramic engine that will need no cooling or lubricating. It will bring more power and efficiency to road vehicles and aircraft.

According to Duncan Davies, former chief engineer and scientist at Britain's Department of Industry and now chairman of British Ceramic Research Ltd, not only do the latest tests on ceramic engine components point the way towards the all-ceramic engine, but technology will also lead to paper-thin ceramic materials which will be made into the finest crockery and bring major changes to the traditional design and shape of sanitaryware.

The British company reported recently that full-scale trials of a diesel engine fitted with ceramic piston crowns had produced encouraging results.

Engines fitted with ceramic piston crowns had been tested for many hours without failure of the ceramic. One of the problems had been to establish the reliability of ceramic components under stress and over long periods, because the material was traditionally brittle.

Normally, ceramics used for mechanical duties in casting have a life of an eight-hour working shift. But in an engine it would have to produce reliable performance over years.

So far there has been no failure because of any brittleness. A diesel engine with ceramic piston tops can run at higher temperatures than normal, and in doing so can achieve better combustion with better control of its exhaust emission. The use of ceramics will allow higher performance in a diesel engine.

A diesel engine vehicle normally operates at temperatures of up to 900°C. But this can be increased to 1300° with the use of ceramic components. In jet engines the need is for turbine blades to withstand higher temperatures. Small turbine blades are now being injection-moulded into intricate shapes by using technology from the plastic industry.

Telephone for remote areas

A SOLAR-POWERED wireless telephone system developed by an English firm could be an ideal communication service to remote rural areas in developing countries. The caller's voice is transmitted to the country's national telephone network via the nearest exchange by a solar-powered radio system.

One form of the system has already been installed in Turkey. Several Asian and Latin American countries have expressed an interest in the system.

LONDON PICTURES SERVICE

Unknown hazards faced by women workers

WOMEN WORKERS in the semiconductor industry suffer from deteriorating eyesight besides being exposed to suspected carcinogens.

A study was published recently by the International Labour Organization, examining the problems of young women employed in Asian Free Trade Zones. The study focuses on the semiconductor industry because 90 per cent of the staff are women between 16 and 23 years of age.

Such jobs are made attractive for women, with benefits in the form of subsidized canteens, company buses, recreational facilities and special bonuses for high output because of the painstaking work involved.

The girls do not know about the existence of these invisible hazards or tend to disregard them. Many refuse to wear protective masks because these impede the attainment of high productivity quotas. At present some firms are trying to solve this problem by setting up joint worker management safety and health committees.

Stomach butterflies can be recorded

STOMACH BUTTERFLIES is a stressful situation; they aren't all in your imagination. Using an electrogastrograph, an external electrical monitoring device that is to the stomach what the electrocardiograph is to the heart, Larry Vandecreek and his colleagues at Ohio State University in Columbus have been able to measure the "butterflies".

Like all muscles, the stomach is stimulated by electricity. Electrical signals from the stomach were first measured in 1922. However, it needed sophisticated electronics to isolate the weak stomach signal from the strong heart signal.

Motion sickness triggers erratic electrogastrograms. Anorexics, preliminary data indicate, get butterflies just thinking about food. The technique can be used in biofeedback experiments to see if stomach sufferers can be trained to normalize their stomach contractions. This procedure could also be used to screen astronaut candidates.

Don't mix your fibres

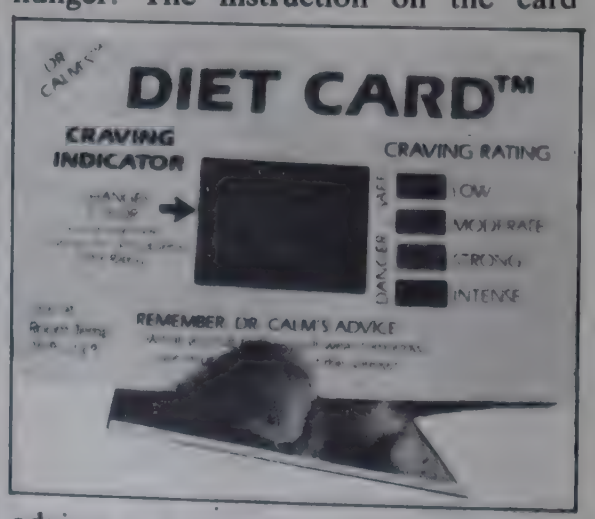
POLYESTER-COTTON blends can be dangerous. Polyester-cotton blend clothing burns about 25 per cent faster than clothing made either from pure synthetics such as polyester or from pure cellulosic fibres such as cotton and rayon.

According to Howard L Needles of the University of California at Davis, USA, a pure synthetic fabric melts and falls away from the body as it burns tending to self-extinguish. The blends, however, hold together giving flames and heat a greater chance of causing body burns.

Previous research had suggested that polyester-cotton blends should be less flammable than pure cotton, but these blends have been involved in a disproportionate number of clothing fires. Fabric weight per square metre, it appears, is the largest factor effecting flammability. Another major factor is obviously apparel design. In comparison to a tight fitting dress, a loose billowing outfit gives a good air-fabric mix that spreads flames around the body.

Diet Card

A PLASTIC diet card measures people's craving for food by the temperature of their thumbs. Pressing a thumb against the card changes a patch of colour: the deeper the colour, the stronger your hunger. The instruction on the card



advises you to measure your desire for food — and then drink a glass of water.

Manufactured by an American company, the pocket diet-reminder helps break the between-meal snacking habit. It is supposed to be more effective than health spas, weight-loss clinics, and special diets.

If you were born in spring...

... YOU ARE more likely to be allergic to pollen than to other substances.

According to a report of a study of 207 people with allergies, conducted by Italian physicians — a statistically significant association was found between pollinosis and spring time birth.

This connection could be a secondary association, to the genetic component to allergies and it's possible, for example, that allergic parents may avoid conceiving in the fall for some reason. Or it could be attributable to lasting effects of pollen on the immune system of newborns, who have not yet developed the ability to neutralize airborne allergens.

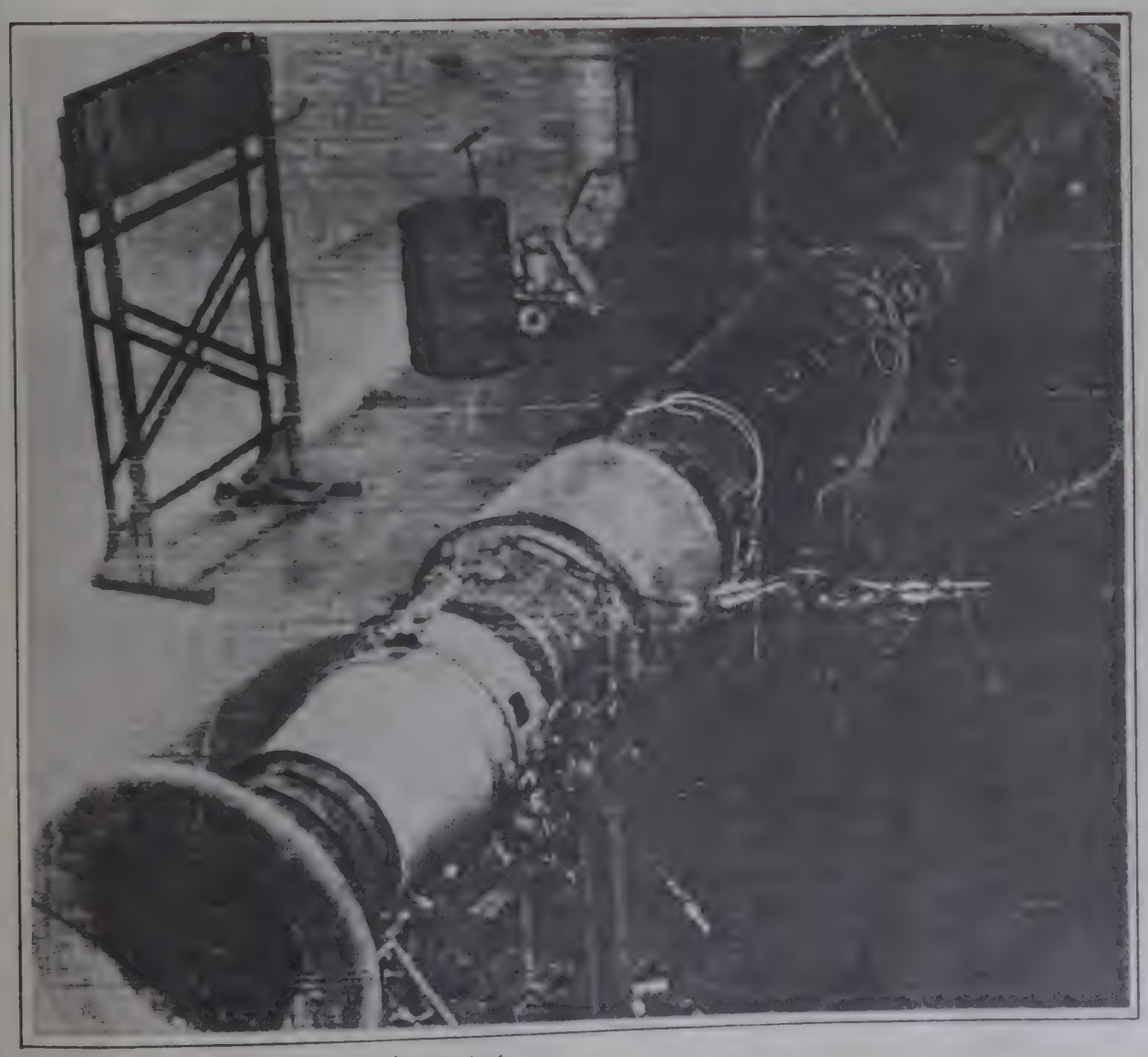
A tale to tell... a dream to remember

In spite of an early start, our aeronautics is not our own. Not yet

S N ROY CHOUDHURY

AERONAUTICS IS perhaps one activity which commands goodwill from all quarters, perhaps because it concerns the defence of the country. Why then is it in such a bad state? Several articles have appeared in the press in recent days trying to analyze why, in spite of a rather early, heady start, aeronautics in India (excluding the licensed manufacturing activities of foreign aircraft), has made so little progress. And if science and technology in other fields — for example, nuclear energy, space, agriculture, electronics, medicine, etc — could make some reasonable strides, why could't aeronautics?

Why, indeed? These articles appear to suggest that this could perhaps be either due to a persistent inadequacy in our management syndrome, incapable of meeting the needs of the situation, or, because of some inexplicable reasons, a large number of incompetent aeronautical engineers and scientists had apparently invaded, and continue to invade, and run our aeronautical industries and R & D establishments.



Orpheus 703R-2000 K reheat engine on test

One cannot overlook the fact that our country continues with expensive licensed manufacturing activities, inspite of more than two decades' efforts in the field of military aircraft design and development. Although our publicized national goal is to build an indigenous frontline military aircraft for use in the 21st century, as matters stands now, we seem to be far from our goal, at least by a decade. Even this estimate may seem optimistic to some.

That there always exists a big gap between design, development, producing a worthy combat aircraft, and licensed manufacture, is often not realized, even by those who are involved with licensed manufacture and who make use of the manufactured items. The latter activity does not require high intellectual inputs. It does not need to be backed by a group of knowledgeable and capable people with many years of dedicated R & D work behind them, and lessons learned from failures. Aeronautics, like brewing good wine, is a culture based on tradition. Like quality wine, it can never be produced by upstarts. In India, as matters stand now, almost as a rule, non-practising aeronautical scientists and engineers are considered to be best suited to control such activities (perhaps for valid reasons).

The end-product of licensed manufacture results from many different finished and semi-finished components, materials, electronic systems, instruments, etc imported and then assembled here. Such steps may not be entirely unnecessary. They may even be economically justifiable for our manufacturing programmes. But they do point to our inadequacy in certain critical areas. These areas become relevant when we wish to start indigenous design and development activity. Any such activity needs, of necessity, prototype fabrication of new parts and components. Our inability to do so in certain critical areas puts us in a very difficult situation.

Licensed manufacture also tends to bring in a false sense of technological excellence, when we roll out from our hangars the frontline aircraft of the world. We soon start wondering why aren't we able to design them ourselves, not realizing that our deficiency in matters of fabrication and shortage of components is only one aspect of the problem. A far more serious aspect is the mind and culture that go with such activity. They are not at all involved in licensed manufacturing activities.

Not that serious and systematic attempts to bring the intellectual and

technological gaps have not been made since the late fifties. Unfortunately they did not work in our context. One wonders why? The gap that exists between the competence we have and what we need to make a frontline military aircraft is widening with time. It is perhaps fair to mention that if our inability to come up with the best is taken as the criterion then nearly all our other so-called successful efforts in science and technology (S&T) are also quite behind international standards. But even substandard efforts in such areas are able to serve our society to some extent. Consequently, they are appreciated. This is not possible in military aviation. It must match the world's best, to be of any use to a nation.

One of the major factors which has always been identified as the key to aeronautical development from its very inception is, the engine which propels the aircraft. It's worth talking about because it may be the reason for our present dilemma. Till recently, when it'was the electronic inputs that had become large, engine costs were often more than 40 per cent of the total cost of civil aircraft, and even more in military aircraft. They played a primary role in aircraft and continue to do so. Did we realize the importance of this, and also consider the emerging scenario on the importance of electronics in the future? No, we mainly concentrated on the development and use of the indigenously made VHF/UHF sets. Was there something which the Indian aeronautical S & T scenario grossly missed, which prompted earlier R&D attempts to be set aside mindlessly, and without a vision for the future? Are we, in this process, merely chasing a mirage without understanding the fundamentals of the developmental forces related to this complex subject?

If one analyzes the several pioneering efforts in aeronautics, one observes that there have been two equally important factors that lead to success. One is related to an emphasis on continued development when several "marks" of the basic aircraft were made, each improving upon the previous one. Every successful aircraft was not freshly designed. That technology development is essentially a continuing process, is perhaps illustrated more glaringly in aeronautics than in any other discipline. One has merely to turn the pages of *Janes — All the world's aircraft* of any year to convince oneself that this is so. The other contributing factor is the quality of men behind aeronautics' success

Engine power

THE INSTALLED horse power of the first flight at Kitty Hawk, North Carolina, USA, was only 12, through a four cylinder water cooled engine. Soon three more marks appeared on the scene, and the installed power went up to 24 HP, or about 18 kW. The current demand is on engine having power generation capacity exceeding 12 MW in a single seater fighter aircraft, and taking into account the leaving energy of the reheated jet engine, the need is for more than 16 MW. This power is installed in a space not greater than 3.0 M^3 and managed by just one person over the entire power output range, in addition to navigating, fighting, bombing, and keeping a watch under most difficult and hostile conditions, for the preservation of both himself and the expensive aircraft. To appreciate the magnitude of the task on design and use, one has only to take a look at a 10-15 MW power house, and compare the difference.

To highlight the relative contribution from the engine during the early phase of aeronautical development, it may be pertinent to quote Sir Leonard Bairslow, the famed scientist on aeronautical research. He stated in 1923, "Our war experience showed that whilst we went forward as regards to horsepower we went backwards with regard to aerodynamic efficiency." Colonel Neo Oglive, one year earlier in 1922, stated "In coming to consideration of the progress in aerodynamics, during the period, it is accurate to state substantially there was none." The above sentiments were generally true so long as the aircraft flew subsonically in the early years. At the same time, it would be wrong to imply that aerodynamic refinements to reduce drag and to improve upon the control and stability problems did not play any worthwhile role during this glorious phase. The fact is that most of the early aerodynamic principles involved were formulated by Sir George Cayley and others in 1850's and already well studied for practical use, years ago, by those who had experimented with gliders before the powered flight in manned aircraft. The cambered wing, the importance of centre of pressure and its shift, the influence of leading edge slats, trailing edge flaps, wing tip shapes, etc with regard to lift and drag under different flight conditions were generally known, for example, through tests conducted in the first wind tunnel built in 1871 for the Aeronautical Society of Great Britain. This is evident from the fact that the first flying machine Flyer No 1 in 1903, the DeHavilland's famed Tiger Moth of 1915, the Bristol fighter in 1917, and several other later planes such as Hawker Fury in 1930, all had bi-planes. They were genetically the same and had aerodynamic approaches with similar cambered wings. There were undoubtedly aerodynamic refinements. But the major difference between them were the installed power, which had increased progressively from 12 hp to 525 hp, developed by a water-cooled Rolls Royce Kestral engine in about 25 years' time. The impact of this development can be seen from the fact that at the first and the most famous aviation meet in 1909, in Rheims, France, Henri Farman covered 180 kmph in 3 hrs to win the Grand Prix de Champagne, Glen Curtiss won the Gordon Bennett cup for the fastest two laps of the course with a speed of 64 kmph, and Latham was awarded the altitude prize gaining a height of 150m. In 1930, Hawker Fury exceeded 320 kmph at 5000m, with a Kestral engine, just 27 years after the first manned powered flight. In between, such flying machines had fought a war successfully carrying machine guns and bombs during 1914-18, only 11 years after the historic flight in 1903. After the war, the civil use was slowly unfolding, simultaneous to a powerful concept of deterrent air power.

The Hawker Hurricane, the Supermarine R J Mitchell (and his successor J Smith), Spitfire, Messerchmitt Me 109, North American Aviation Mustang, and Republic Aviation Thunderbolt are the well—known monoplanes which followed next. Aircraft fought wars for the second time, now with more powerful flying planes with greater fire power. They all demanded greater installed power, and this was provided in progressive steps in several marks of these, and each step meant improved performance. By the year 1939, a version of Me 109 established a world record of 750 kmph which remained unbeaten until a jet engine propelled aircraft exceeded this in 1945. Spitfire, one version of the MK XIX, flew at a speed of 750 kmph, with a Rolls Royce's Grifon engine, developing about 2250hp, almost around the same time. This engine had developed twice the power which MK 1 of this aircraft initially had. This development of engine power had helped the Spitfire to perform in several roles and it became the legendary fighter aircraft of the world till the end of second world war.

With the increase of engine power, the efforts to make them lighter with better materials were equally dramatic. By

stories. The pioneering man came first, and patronage in the shape of management came next. Not vice versa. For continuous development activity, the important ingredient has been a continuous increase in the installed power rating of the engines in a particular type of aircraft. This process continues even now, but it was more pronounced during the earlier phase of aeronautical activity, spanning a period of 25 to 30 years since the first powered manned flight took off on 17 December, 1903 (see - box).

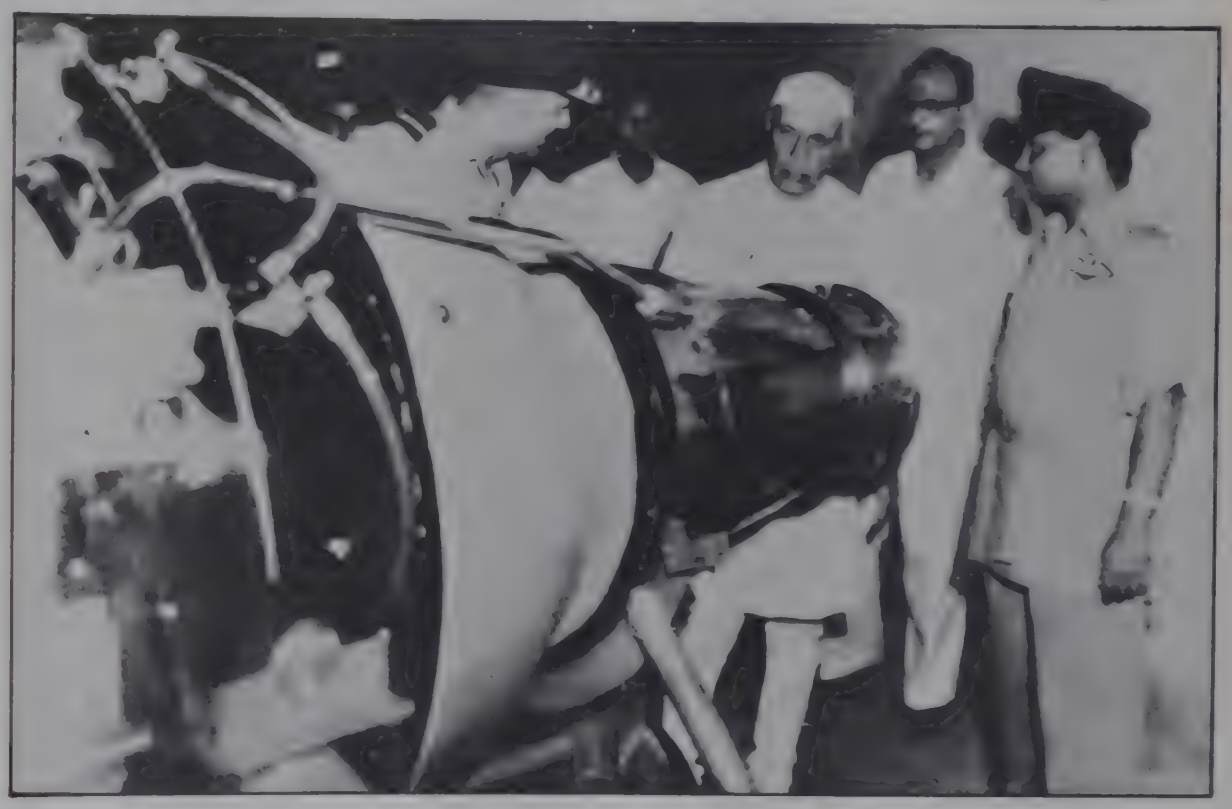
Since we are familiar with the MIG aircraft, it may be worth illustrating this aspect of continued development noting that the first MIG-15 was designed around 1943 and in service in 1949. The man behind the design was Colonel-General Mikoyan. This was followed by MIG-17, a progressive development of MIG-15 to be followed by the moderately supersonic MIG-19 in 1955. We purchased and subsequently manufactured the famed Mach 2 class MIG-21 in the sixties and seventies. Each of these variants had improved power rating from RD11F leading to R13 engines. All these were designed by Mikoyan, when MIG-21 itself had several variants. Since then we have had MIG BIS, MIG-23 the variable geometry supersonic aircraft with the still more powerful R29 engine, and now the MIG-29. Published reports suggest that MIG-23 is powered by a 9.5T thrust class of engine, with powerful afterburners. It can attain a maximum speed of Mach 2.3 and has a service ceiling of about 20,000m. Compared with the power of MIG-15, there is a three-fold increase. The thrust-to-weight ratio has improved from about 3 to about 8 to 10, now demanded by aircraft designers. So it is a story of continually improving the aerodynamics of the engine, better materials, improving mechanical engineering and design concepts and more precise control systems, now with digital electronics.

The lesson which one could have learned from the above is that from base level, one could develop continuously improved aircraft to serve society, through a continued process of engine and airframe development. Did we learn it? Let's see what happened in India, when the very first venture to catch up with the world military aviation was made in 1956, an era well into the jet age.

Kurt Tank, a well-known German designer, was invited to establish a design team in India, to develop a Mach 2 fighter aircraft. The design, designated as HF 24, was submitted in December 1956 for our Government's consideration. It was designed around BOr 12 SR engine (SR stands for Simple Reheat of 1400°K reheat temperature) to be developed by Rolls Royce (then Bristol Siddley Engine Ltd). Two such engines were to have been used, each having unreheated thrust of 3100 kg and with reheat, about 4000 kg at sea level standard atmospheric condition.

This proposal was made in the Third World at a time when things had moved ahead, though not to a very great extent, in Europe. Although jet aircraft were already in service abroad, both for military and civil use, and our country had also moved into the jet age with subsonic aircraft like Vampires, Hunters, Oregon (Toofani), and later by Gnats (renamed Ajeet in India) supersonic flights were still not a common feature in 1956. The first British fighter to exceed the speed of sound in level flight was the English Electric Pl, and before the end of 1959, the developed Mark PlB, known as Lightning, had made several flights attaining Mach 2 Plus. Thus, in 1956, the proposal to build a Mach 2 fighter aircraft was not an inappropriate and belated decision. In fact, the early introduction of jet aircraft and the simultaneous attempts to manufacture, design and develop these within the Third World inspite of a poor industrial base, showed the kind of statesmanship and the S & T vision the country had at the time. Did we live up to that in the subsequent years? (It is worth remembering that the decision to develop the Mirage aircraft with a single SNECMA Attar engine in France was also taken at about the same time.)

The Mirage III C was first flown in 1960, when HF 24 also flew in 1961 for the first time. They were similar air-



the time the piston engines reached their peak capability during late 1930's, the engine weight was reduced from about 2.8 kg per hp in 1909 to 0.400 kg in 1949. Thus, the weight of the aircraft did not go up to any significant extent, but it had considerably more installed power. The performance of the aircraft had therefore markedly improved. One could fly at about 750 kmph, climb to 7,000 m in about 8 minutes, and the service ceiling were about 10,000 m.

Even in civil aircraft one finds that similar continued development drives led to several successful stories. The Douglas DC-2 carrying 14 passengers had two 710 Wright Cyclone engines. This successful aircraft prompted the design of the perhaps most famous transport aircraft of all time, the DC-3 (Dakota) now with two 1200 hp engines. Obviously performance had now improved and this encouraged the making of many more DC series of aircraft, all with increasingly greater installed power. Such success stories are endless.

Me 262 had established the world record, with a Jumbo 404 Jet engine, which was initially not so reliable. After several fatal accidents, the aircraft entered the squadron service in 1944 and was flying at a speed of 840 kmph. The service ceiling had increased to 13,000 m. The jet engine era had firmly emerged by about 1945. F1 Gloster Meteors were in service by then with two Rolls Royce Wellan 2 engines, each developing 800 kg thrust. The demand for more powerful engines continued till recent times with jet engines, for example, in several MK's of Mirages, F-16, and Hunters.

SNR

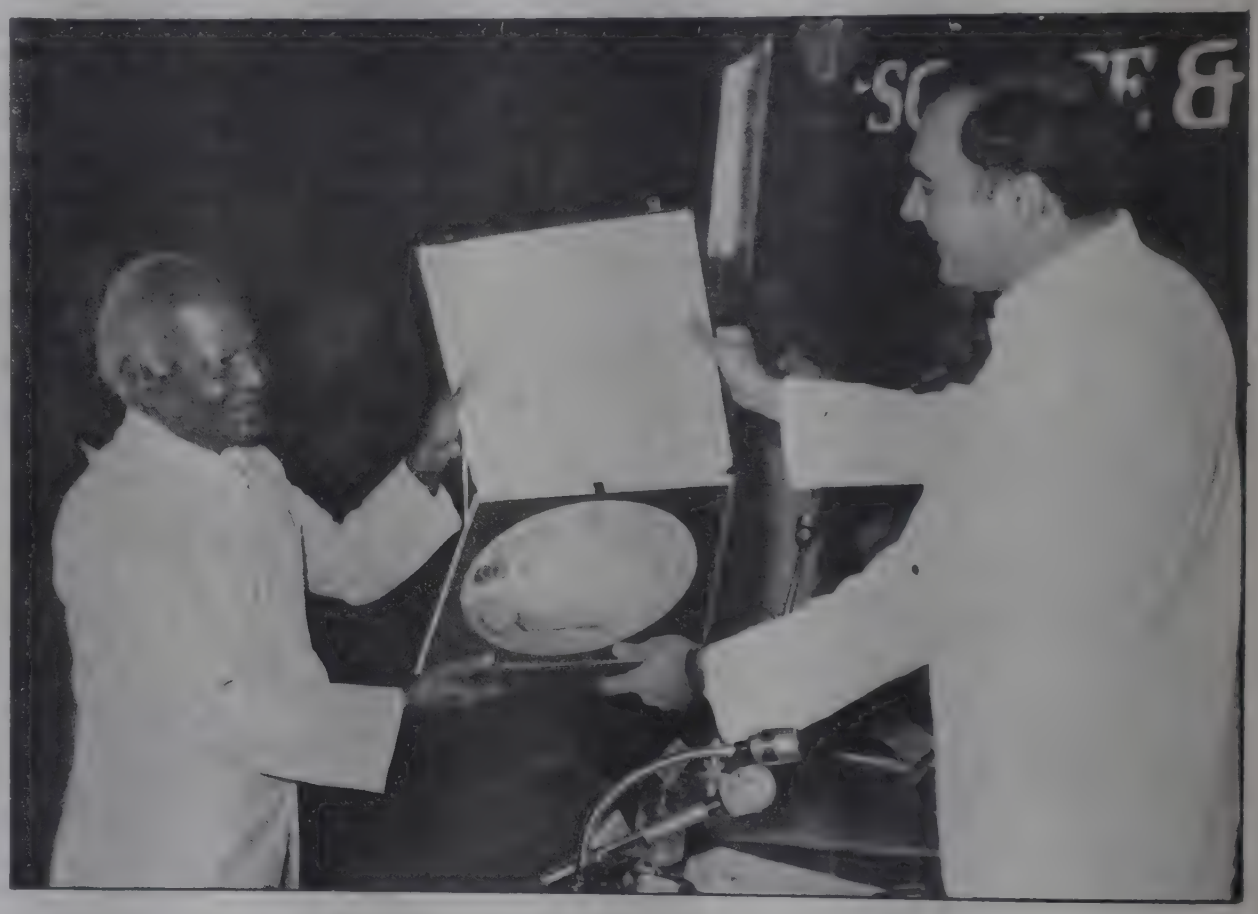
craft in many ways, except that HF 24 had two engines. The Mach 2 version of Mirage F1 with Attar 9K engine (7636 kg thrust with afterburner), a successful export version, had non-afterburning and afterburning thrusts similar to that projected for HF 24. The engines in both the aircrafts were low pressure ratio single spool turbojects, with uncooled turbine blades. The thrust to weight ratio was about 4.5. (in the reheat mode). A salient difference was that France did not opt for an imported engine. They had simultaneously taken up the design and development of the Attar engine as well, with the assistance of a few German designers, but involving their own people fully.

HF 24 met the first setback when the B.Or 12 SR engine development was dropped by Rolls Royce, because the NATO backing to develop this engine was withdrawn. It flew with two very low powered B.Or 703 unreheated engines (2200 kg thrust). This was a marginally developed version of B.Or 701 engine already in use in our Ajeet (Gnat) aircraft. Incidentally, the first Mirage also flew with a very low powered Attar 101 G turbojet engine with a afterburner thrust of 4500 kg. Taking the cue from earlier experiences on aircraft development, the Gas Turbine Research Establishment (GTRE), formed in Bangalore in 1961, took up a programme of continued development of the B.Or 703 engine, to progressively improve upon the installed thrust of the aircraft.

The attempts were in two directions. First, to develop the afterburners, and then to develop the basic engine itself and add afterburners to the more powerful developed engine. Such steps would have eventually improved upon the installed thrust by about 75 per cent. The 1700°K reheat system was fully developed, type certified after several hundred hours of bench test and flight developments. It was cleared for production. The 2000°K reheat system was developed up to that point when it was taken to the National Gas Turbine Research Establishment (NGTE), UK for high altitude testing (India does not have this facility). The results were encouraging as can be seen from the report submitted by NGTE. The developed version of the basic B.Or 703 engine, designated as TS16, with a transonic first stage in the compressor, replacing the existing subsonic stage, had also run for the first time in May 1974, in the presence of the then Chief of Air Staff. There was little to doubt the success of these well conceived steps. They were reasonably well established through much dedicated and hard work in R & D, with a hope to develop HF 24 to its logical conclusion. The finally expected total unreheated and reheat thrusts from two installed TS 16 reheat engines, each developing about 7850 lb thrust, would have been quite similar to an Attar 9K afterburning engine. The first MK II version of HF 24 with 1700°K reheat system was getting ready for production in 1973, when the production drawings on the aircraft and engine were nearly complete.

But the programme to develop the HF 24 itself was abandoned, and it brought to a complete halt the hard-work that had gone on for a decade. One still does not know why this decision was taken. The next step was a decision to take up licensed manufacture of a Jaguar aircraft of British origin. While HF 24 was basically designed as an interceptor (air superiority) aircraft, the Jaguar was a ground attack aircraft. From this one may conclude that the decision to abandon the HF 24 project was taken because our operational requirements had changed by that time. We had a war across our border just prior to this decision, and the experience gained might have tilted the Government in favour of a low flying Deep Penetration Strike Aircraft (DPSA). In any case, by this time we also had the famed MIG 21 as the air superiority aircraft from USSR.

Even if that were so, the decision did cause a set-back and was a severe blow to the very first attempt the country had made to catch up with the world community in an area of S & T. This phase of engine development was a constant struggle, when several foreign engines were considered for HF 24, along with the design efforts which were going on at GTRE. Then there was that fateful accident on 10 January 1970 when the test pilot flying a reheated version of HF 24 was killed. He was more than a test pilot. He was an ardent supporter of GTRE's activities. The accident was not attributed to engine development but it may be difficult for outsiders to appreciate the turmoil one went through those days. One had expected encouragement and support for indigenous development, but had often to battle for it instead. The developmental work had to be continued at the same time, and it needed all one's mental will to succeed with constant fear of rejection hanging over one's head. (This process perhaps continues even now.)



With the decision to drop HF 24, never formally conveyed to GTRE, there was an unavoidable feeling of dejection. It was felt that we were moving away from the proven path which had led the western societies to success. The atmosphere from 1962 to 1972 was one so very characteristic in aeronautical development world. There was much excitement and hard work. All this came to an end — suddenly. HF 24, a foreign designed aircraft, with an underpowered foreign engine continued in service for a while to perform some secondary role. That was the end result of a decade's efforts in military aeronautics in the country. Was the decision to scrap it necessary in the wider interest of aeronautical development of the country?

A mild attempt to revive developmental work on the engine was made

at GTRE, when the unreheated TS 16 was considered for continued development of the very successful Ajeet aircraft replacing the unreheated B.Or 701 engine. A super Ajeet concept was briefly considered but dropped. Again, one found that what made a success story elsewhere was apparently not a path to follow in India. There were always supposedly "good" reasons not to follow it. An era to consider the design of another new indigenous aircraft emerged around 1974. The first requirement was presented just before the HF 24 story, in 1972. It was for a long range ground attack aircraft.

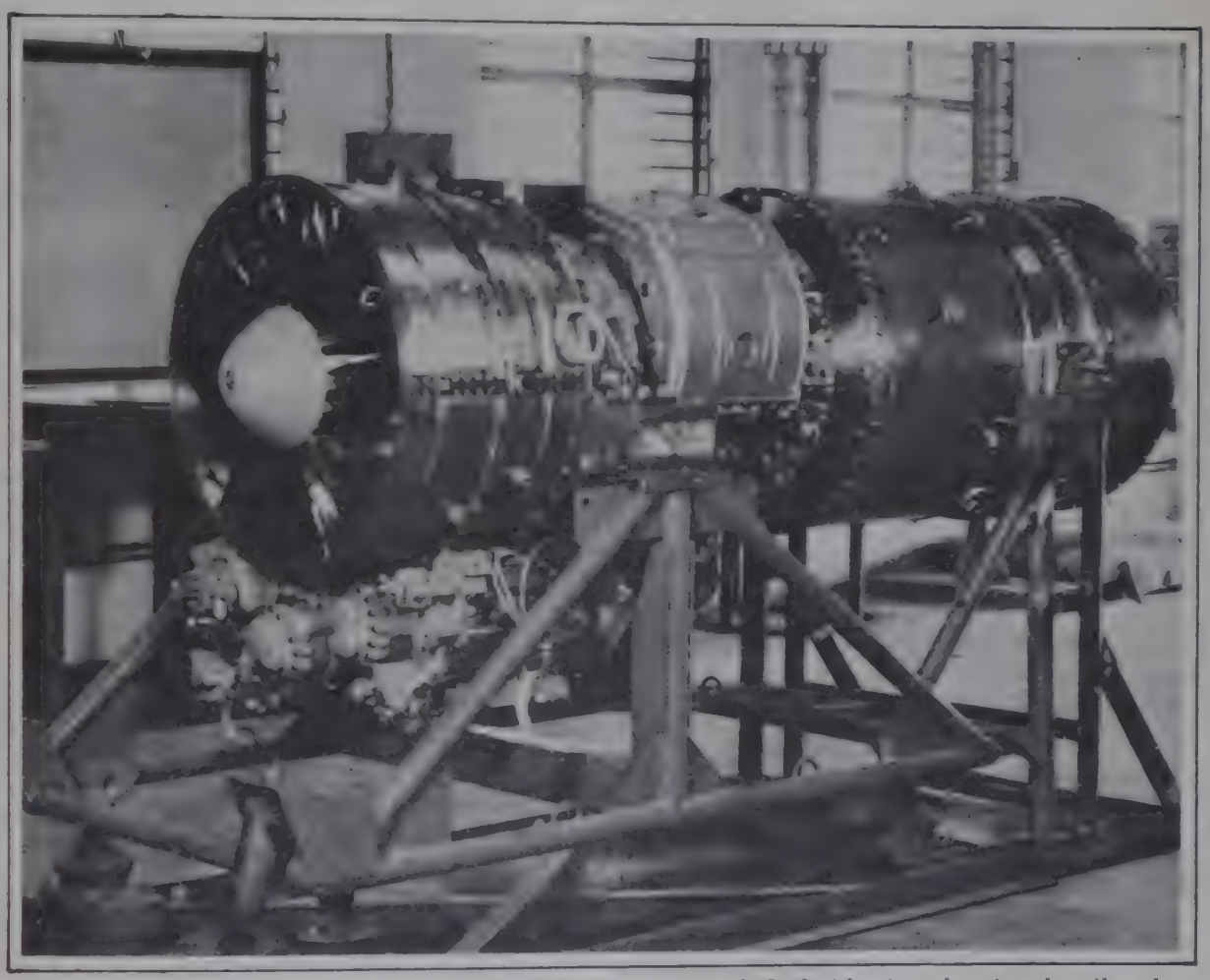
It is necessary to realize that a continued development process had all the advantages over a totally new and *ab initio* attempt to design and develop an aircraft in our context. We do get a base aircraft, when we take up a licensed manufacture, and during the negotiation stages, more often than not, they are bought after the seller makes presentations to elaborate that the aircraft has a very significant stretch potential — as was done during the sale of the Jaguar aircraft. Much of this was true but not pursued. Although we have taken up the maximum number of licensed manufactures, we have not tried to develop even one.

One must realize that the country does not have an aeronautical material base. There is nothing new invented on the aerodynamic front, if one has to go by the published reports or public claims. The same may also be stated for the aircraft structural design aspects. No new navigational system have been devised. The instrumentation technology remains the same. Therefore, purely from thelogistic and easier resource mobilization points of view, a school of thought had favoured the continued developmental approach, with improved engines, indigenously developed, as was the practice elsewhere. But there was an equally strong lobby against this. It consisted of the "purists" who wanted to do things of their own from scratch and develop a new aircraft. The emphasis continued for a long-range ground attack aircraft. That being so, one did not find anything new in their new postulations, scientifically or technologically. These so-called "new" aircraft concepts had adopted aerodynamic and structural design features which were the same as HF 24. In fact, everything was more or less the same, except that a bigger and heavier aircraft emerged, with a larger fuel carrying capacity. This continued to be debated with ever changing operation requirements with time. The needs for improved performance levels on turn rates and acceleration to maximum speeds, climb, supersonic speeds, and so on were felt and the aircraft based on HF 24 technology tended to be one demanding more and more engine power, with diminishing returns, and increased aircraft weight. All the same, everything was assumed to be known and possible, except that one did not know what engine to use. It is in this context the engine became the much talked about missing link. So the search for a foreign engine began.

Once again we did not wish to learn from the HF 24 episode. A high bypass ratio RB 199 engine was the most favourite among all. It was an engine designed for a fighter bomber, Tornado — a joint venture between UK, West Germany and Italy. Powerwise, it was about the same as the one used in MIG 21, although RB 199 was much more efficient from the fuel consumption point of view. It provided the range but not the combat performance under the high ambient conditions which we experience. The R 13 engine of MIG 21 was suitable to try out all the newly conceived aircraft's capacity, except the range. The suggestion was to let the R 13 engine which was then made in the country be adopted, till an indigenous engine was developed. Somehow, the demand for RB 199 prevailed and such suggestions to use what we had were set aside.

GTRE had realized early in 1968 that after the phase of continued development of HF 24 with the improved and derivative engines from B.Or 703, a new advanced technology powerful engine would be required. Like most of the engine development of the past, the essential motivation for the GTX design was to meet a specific requirement beneficial for low level combat operation under high ambient condition as was the need expressed then. This had to be achieved with the highest possible fuel economy. The usually designed Gas Turbine (Jet) engines lose power rapidly with the increase of temperature at the compressor inlet face. This can happen either due to high ambient condition, or high aerodynamic temperature with high forward speed at low levels. Thus, while a military aircraft fitted with a conventionally designed engine can take off comfortably with war loads, it often has considerable difficulty to get airborne under hot ambient conditions, like at ISA+25°C (or 40°C) temperature condition. The loss of power at take-off can be about 20 per cent.

At the same time the maximum level speeds or the combat capability also reduces drastically due to additional characteristic drop in thrust with foward speeds. To maintain high levels of performance, the use of



GTX engine without the reheat pipe on the engine stand (Left side view showing the oil tank installed in the waist of the engine)

afterburner which consume large quantities of fuel has to be resorted to. This results in a reduction of the radius of action with conventional designs. The GTX is an innovative design concept, when these disadvantages are by and large removed. At that time in the early 70's, no engine had existed with this concept. Not only can the take-off thrust be maintained under high ambient conditions but there would be no further reduction of thrust at high forward speeds. The afterburner can now be less used. Repeated analysis had established that for low level combat applications, this design was better than RB 199, both at standard temperature and high ambient conditions.

Although the GTX engine design was suggested in the early 70's, even to get on with the work depended on assessments of its relative merit when compared to RB 199. It took time. To some, it would appear, nothing other than RB 199 was acceptable. Although one cannot be absolutely sure, one often got the impression that the changes over the years were more to suit RB 199. The desire to design a totally new aircraft encouraged the Air Force's imagination to run wild, and why not? A new era on military aircraft was round the corner, for example Panavla Tornado, General Dynamic YF 16, Grumman 14A, Mc Donnald Douglas F-18, Northrop YF 17, MIG 23, and so on. The thoughts appeared to have been that if we were to have a new aircraft which would take about a decade to design and develop, and at least another decade to remain in service, it was best to look into the distant horizon. The specification worked out to be a simulation of the best of all the known futuristic aircraft, combined into a single package.

There was an endless debate on our needs for ground attack and air superiority aircraft. The aircraft also had to be as small and light as possible. Several committees, study groups and high level meetings tried to arrive at a conclusion,when the Air, Force's specifications changed rapidly, perhaps because of the rapidly changing situation abroad. Thus, often one did not know, when one had gone to attend a meeting—always a high-level one — whether the discussion was related to a ground attack or an air superiority aircraft. So a simple formula was adopted. The aircraft were given primary and secondary roles. It saved embarrassment, because to change from one type to the other, all that needed was to switch the words. Yet the two types of aircraft are entirely different, aerodynamically and with regard to propulsion needs. This uncertain situation was ideal for the decision making body to be indecisive. Also, the situation was ideal for the mind to stop thinking, or take any initiative. Once that happens, no research scheme can generate, as happened during this time. Otherwise, why were no research projects initiated on advanced aerodynamic concepts and tried out in an existing aircraft,like the HF 24, or MIG? Mirage 2000 has two winglets stuck on the sides of the air intake. Could we not try out this on HF 24, for example, after trying it out in our wind tunnels? Similar questions were raised about fly-by-wire conformal ECM, composite material structures, wings, and so on. All that happened was what we are really good at: that is, talk, writing minutes of meetings and ending with platitudes. We did not venture out to experiment on any new thought or a concept even though it was clear that a sea change was needed to meet the new performance requirements. One got the impression that R & D on all the advanced concepts were redundant, and they could be bought out as accessories even though it is known that most of them are to be integral parts of the design of the aircraft from the very beginning. Simultaneously, there was one more problem the researchers faced.

An interesting norm which existed then also stopped any enthusiasm or attempt to try out anything new. Research and development work were classified as either "open-ended R & D",that is,when not related to meet a service requirement, specifically, or staff projects to meet an accepted operational requirement of the services. The sanction for the former, due to an apparent paucity of fund, was difficult. Thus no serious R & D ventures on all these relevant aspects which are needed to initiate a new design and development of an advanced technology combat aircraft were either initiated or sanctioned, although the need for these was now increasingly apparent.

The work on GTX was however continued, through the patronage of the Defence R & D organization, thanks to a decision earlier taken by the Subramaniam Committee in 1968 and also through the patronage of the Scientific Adviser around this time. He was convinced about the approach which GTRE had taken through, for example, TS16 and GTX. A decision to go ahead with a demonstration activity was given in 1974, and a sum of Rs 20 million was released in 1975 to make one prototype. The demonstration was completed in 1980. This was certified by a Government appointed steering committee. Although one may view that the time taken was too long, it is necessary to realize that GTRE had to gear itself up from a very low infrastructure level to be in a position to manufacture a prototype of an advanced technology engine, in the strictest sense, with newer materials and technologies not attempted so far in the country. For example, GTRE was first to handle fabrication with Titanium materials, use electron beam welding and numerically controlled machines, adopt electro-discharge machine technics, and so on. This two-shaft engine was to have three squeeze film bearings out of a total of only four (more are generally used), cooled turbine blades, wide chord transonic compressor stages — a new approach to fuel control system for the GTX concept operation. It was perhaps the most optimized fixed geometry engine for the purpose.

Other models like GTX 35 were then considered but,at that point of time, an engine needing variable geometry and higher turbine entry temperature, in addition, was considered too ambitious when the fuel control system also became more complex. A total of an additional 800 technicians and draftsmen were to be inducted and trained in house on these methods, soft toolings were to be designed and proved to make the new engine, and full-scale research facilities based on 4 × 9,000 hp turbomachinery prime movers were to be developed in house. Engine test beds were to be designed and made. All these were to be done along with the design, component research, detailed drawings with standards to be formulated,and so on. The task was far from easy. It needed dedication of a higher order and there was no shortage of that inspite of the past. The will to succeed was very much there. This is evident from the fact that the engine was first run in 1977, and reached 95 per cent rpm in 1980.

While the debate on the new aircraft went on for a whole decade (1972-81), GTRE kept up its own faith on continued development of aircraft under production. A project designated as GTX-Adour was proposed in 1978, for the continued development of the Jaguar engine and hence the aircraft. The object was to take up a joint venture with Rolls Royce adopting the best of the two engine systems, that is, the GTX, and the by-pass Adour engine which now powers the Jaguar aircraft. It was felt that with the LP compressor design of the GTX which was better than the

Adour's, and also its afterburning system, combined with an improved high pressure core part of the Adour, it would be possible to increase the engine rating by about 28 per cent without increasing the engine weight or the dimension. There would have been some improvement in fuel economy as well. Although the project proposal was initially supported by our Government, the Air Force as well as Rolls Royce after considerable technological negotiations in 1980, to improve upon the Jaguar's combat capability as a DPSA, the Government's need now changed to having an air superiority aircraft instead.

This change was announced at a meeting held just before a team was to leave for UK to discuss with Rolls Royce and British Aerospace about the continued development of Jaguar. Now the directive was to discuss a LAC (light combat aircraft) also. GTRE was caught on the wrong foot again! Not surprisingly, the team returned with a recommendation to consider, in effect, a British Aerospace LCA with a Rolls Royce RB199. The support for Jaguar's further development had vanished. The solitary disagreement voiced was one from GTRE. The volume of business for the UK would increase by more than 300 times!

Along with the proposal on GTX-Adour, thoughts were given to improve upon the aerodynamics of the MIG 21 and Jaguar, adding features like strakes/winglets or fixed canards, which would have made both the aircraft more combat worthy with GTX and GTX-Adour engines respectively. Such steps are known to have brought good results, the most convincing example being Israel's IAI Kfir, which is a developed version of the Delta wing Mirage III C with a General Electric J79 turbo jet, coupled with certain advanced aerodynamic innovations. This aircraft is rated as among the best in its own class.

The GTX had caught the imagination of others abroad. For example, SNECMA, the designer of the engines for Mirage,had offered to work jointly with GTRE to develop a derivative of GTX, designated as GTX (B), for a version of the Mirage 2000. This offer was sent by Chairman, SNECMA, Rene Ravaud, in 1980. None of these proposals for continued development of Jaguar with GTX-Adour, MIG 21 with GTX, or GTX (B) for Mirage received any favour here. Yet these joint ventures could have been the most significant steps to take to stabilize our engine and aircraft development for all time to come. A point to note is that these development proposals were based essentially on the work originated in GTRE. The fallouts would have been a rapid development of technology, greater appreciation of the developmental needs leading to manufacture, and receiving assistance as partners on certain critical areas of shortfalls — for example, cooled turbine blades — reliability and diagnostic tests, flight and simulated tests on the components and the engine system as a whole, analysis techniques, etc. Why the joint ventures were not permitted one does not know. One would have suspected it was due to the "purists" again, until one observed that the same group of people were making what appeared to be endless efforts towards foreign collaborations on aircraft designs, when the request were also made to offer design feasibilities for these sources. What will such types of collaboration amount to, particularly in the shaping of minds and culture, so very essential for aircraft development?

Is it difficult to appreciate what impact all this has had over a period of two decades on people who have dreamt of building aeroplanes, following in the footsteps of others who had succeeded. These people had often put service before self, only to be disillusioned with repeated rejections.

Two incidents

THROUGHOUT THE entire phase of achievement since 1959 some small events kept us alive with the ray of hope of success as if coming from a distant pole star. One such creation was the very first attempt GTRE made in 1961 to design the first ever gas turbine in India. It had a centrifugal compressor with a canan ular combustion chamber. The design rating was about 1000 kg, and designated as GTRC-CF-1 engine. The engine was designed in a store room in an Air Force base, next to a compressor house, which used to shake everything up, with an unbearable noise. However, the task on the engine design was given to us as a challenge to our learnings abroad and in India. The fate of a regular research establishment was made dependent on the success or failure of this. A team of 20 persons, consisting of six post-graduate qualified staff took up the challenge to first run the engine on 1 April 1961, a date fixed by the commanding officer of the Air Force station. (1st April was Air Force Day because only fools and birds fly on that day.) However, the engine ran behind schedule on 9 April 1961. The effort to light up the engine and obtain a stable running condition ended early in the morning after a whole night's struggle. We made two more attempts to ensure that we had got to the first step successfully. We all were naturally excited, and shouted 'Vandematram' — three times, as usual.

I rang up the commanding officer, after giving him a better time for his breakfast to break the news. What I was told from the other end was so shocking that I could not even protest. I only stated, "Yes Sir, I am sorry Sir". The commanding officer was upset that the engine had *not* run on 1 April, and that, according to him, I had failed in my duty. I am to be taken severely to task in his office later, but he informed the Honble Defence Minister Krishna Menon, who accompanied by Dr D S Kothari flew down to see the engine running.

My commanding officer congratulated me and my team after that

On another occasion, while testing the GTX engine, on the test bed, on two consecutive runs, it was observed that there was a fluctuation of air pressure in between a stage of a compressor. It naturally caused anxiety because it indicated an unsteady flow. Arrangements were made to measure the amplitude and frequency, to be co-related with rpm airmass flow etc. On the third day, the phenomenon had stopped on its own. One would normally had felt happy but instead it caused more anxiety. "Nature cure" cannot take place in such matters. The engine was stopped and several explanations were thought of , but none seemed to fit.

It was one of the test launch mechanics who provided the answer. He had tightened up a joint on a tube which was transmitting pressure to the instrument. There had been a leak. He said that he had found it difficult to believe that anything which had behaved all right, all these days, could have picked up such a serious problem, suddenly, so he had gone about his own way to solve the problem.

The senior scientists felt somewhat embarrassed but wanted to make sure. The joint was loosened, and the problem reappeared.

The point is that design and development can never be a one man's job. It is team work right down the line, up to the mechanic, draftsmen, and also those working in the store room, maintaining the right kind of material in the right place.

Apparently, any approach through developing an indigenous engine as the main plank to improve upon an existing aircraft was treated as a useless proposal. At the same time, the approach to design and develop a new aircraft with an imported engine, particularly RB 199, was favoured and debated for a decade, without any decision. It would appear that the emphasis has now shifted to a low by-pass ratio engine F404, powering YF18. Even this engine is derived from F101, which earlier powered YF17. Can we not adopt the R19 engine of MIG 23 instead? Of course this depends on whether we are making this, and how this fits in the programme.

Many of these dedicated people have grown old, obviously. They have set not-so-healthy examples to younger people who may now be in a state of mind which puts self before service, not a surprising fall-out.

It is possible that in a situation when the desire was to go half way house in aeronautical development, as was the case in the country then the traditional approach was regarded as inappropriate. That perhaps is the best reason one can offer for past happenings. What was the traditional approach? It was to rally round people with a dream, which brought about dedication, courage and conviction in serving the society. Perhaps, these were not regarded as important issues. In the same way, it was believed that engine development was not a prime issue. After all, it was felt, that such development could always be had from foreign countries, so why delay the process of designing a new aircraft altogether? This attitude brought down the engine to a level of merely a bought "New Nav Attack System". The most serious outcome of all this is the concept that aircraft design and development can essentially be a management activity to put things together by recruiting suitable people to do a job which the management is assigned to do. This approach surfaced prominently, in late 70's after the dormant phase, of scientific inactivity in mid 1970's. A dreamer, a dedicated persevering man inspiring people to rally round a cause, became an obsolete requirement. That appears to be the final outcome. The question is, how valid is this concept?

On the one hand, we have in front of us the glaring examples of how aeronautics have developed elsewhere, and on them we continue to depend now in every sense of the word; on the other, we seem to believe that in-house research needs are not so very essential, and shortfalls in any, critical area can always be bought out including men of knowledge, from countries abroad. All that is required is to have a well-structured management system, without first building up the men of science and technology having dreams, and helping the dreams to come true. Can we create an environment to develop a Light Combat Aircraft indigenously which must have now included also the specifications borrowed from a French aircraft, British-German European Fighter aircraft based on agile combat aircraft, air superiority tactical fighter of America, and perhaps the Gripen of Sweden, incorporating aspects of track-while-scan radars, holographic head-up-display, pulse Doppler weapon system, infra-red search and tracking-long-range missiles, state of art ECM's, ability to fly in the relaxed stability conditions using fly-by-wire, etc. It is not known whether to us they are not merely technological jargon or whether there are dedicated men with a gleam in their eyes, conducting research and perfecting the technologies on these, on Indian soil. If not, an apprehension does arise, though it may be totally unfounded. Indian scientists and technologists have a characteristic. They tend to be idealists and dedicated under the leadership in whom they can place their faith. The leadership should be equally involved and unquestionably responsible for the eventual outcome. A detached form of leadership with an attitude that "credit is mine, failures are yours" negates all that had helped aeronautics right from its very inception.

It's not just the efforts to develop an engine which went astray. That's only an example. The total actual expenditure on R & D over a period of 20 years, on the discipline of the gas turbine was only about Rs 70 million. This will indicate the struggle one had to go through to establish this subject as an essential component for aeronautical development.

Innovations and pioneering spirits germinate in several kinds of environment. One of them is an atmosphere of a need to overcome the unknown, when there is a respectful encouragement, and appreciation despite disagreements. Subjectivity, particularly at senior levels, is the worst enemy of this environment. Indian aeronautics was in that state in the mid 1970's, when our designers were baffled as to how to achieve the high performance now demanded by our Air Force, with regard to turn rates, accelerations, radius of action, maximum level speeds, etc which were apparently achieved in smaller aircraft abroad. A quantum jump in respect of S & T related to aerodynamics, structure, electronics, control systems and propulsion had taken place, and this became increasingly apparent with time.

Ventures into the unknown were made but through high-level delegations abroad, not through research work of our own in an industrial organization in the country. As a result, we started burning the log at both ends, sitting smugly in the middle. Our incompetence promoted the traders abroad to invade our soil, pollute the minds at decision making levels, while our young scientists sat back with no work to do. The leftover is the increased foreign trade in our ashes.

Similarly painful must have been experiences in other disciplines as well. The gleam in the eyes of many have been dimmed. They need to be rekindled again. It is difficult but not impossible. The newer generation is certainly the better material than those who have faded out. One of the first things to be done is to avoid packing up the suitcase and go abroad knocking on the doors of traders there. Serious and dedicated hard work has to be initiated, and then with confidence earned, one should look for partners abroad, to work together. Taking up joint ventures is an unavoidable need so long as the desire is to work as partners sharing direct responsibilities in our own areas of excellence generated through much hard work done by dedicated scientists and technologists. We seem to be too much in a hurry to approach foreign traders without doing our home-work first.

Finally, could we have hired a Tensing to climb the Everest, unless he had that burning desire to reach that mysterious peak everytime he looked at it? Further, could he have achieved his life's ambition unless an opportunity was given to him? The pioneering man is always an initiator, management comes after, and nothing can ever be achieved in S & T activity, particularly management in aeronautical activity, if that is changed. Innovators can be created through proper management but one cannot build an aircraft without innovators. It will continue licensed manufacture.

Air Vice Marshal Roy Chaudhury (retd) has several propulsion designs to his credit, notably the GTX engine and its variants. He now works as an energy consultant, with special emphasis on Total Energy Systems, and commercial energy developments through bio-mass wastes using gas turbine based generating methods.

2 + 2 = FUN

Go forth and multiply

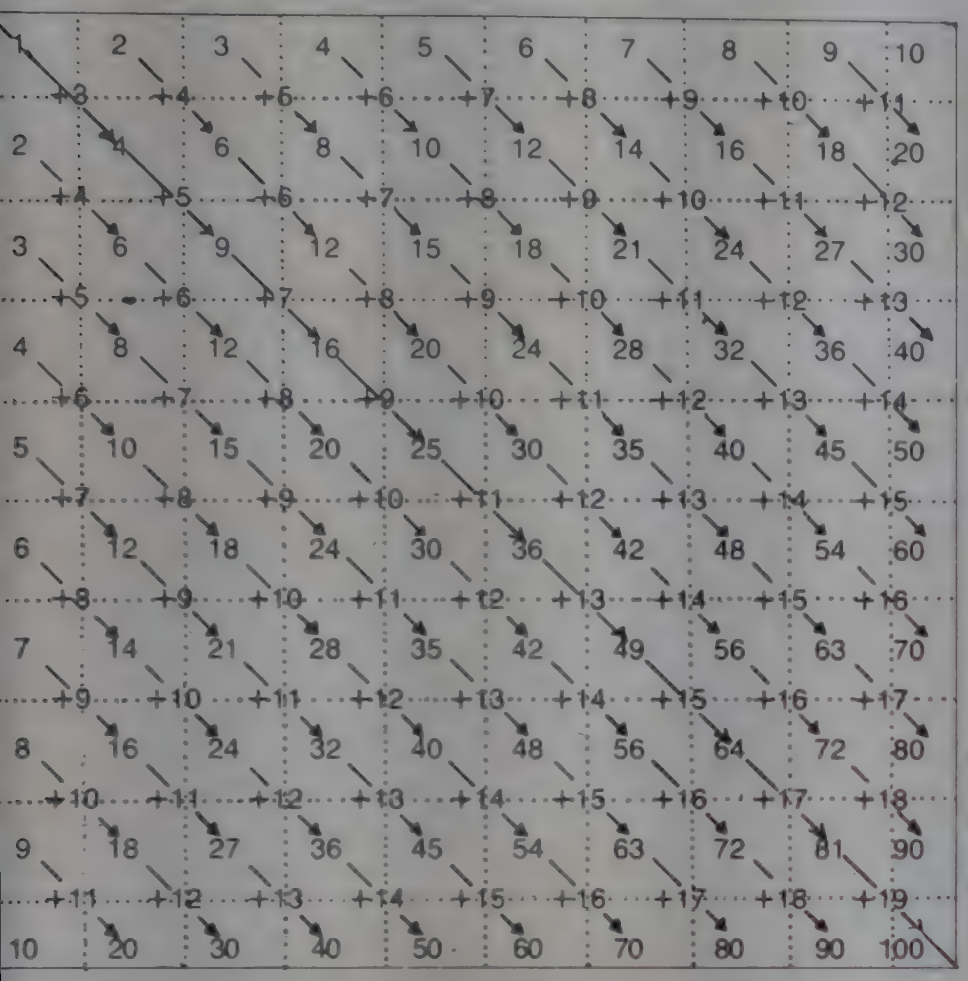
THE MOMENT we read the words "multiplication table", our mind tunes on to the sequences "two ones are two", "two two's are four" and so on. It's the way we learned, remembered and applied our multiplication tables at school.

But can we look at them in an unusual way?

We certainly can.

Look at tables 1,2,3, and 4.

Table - 1



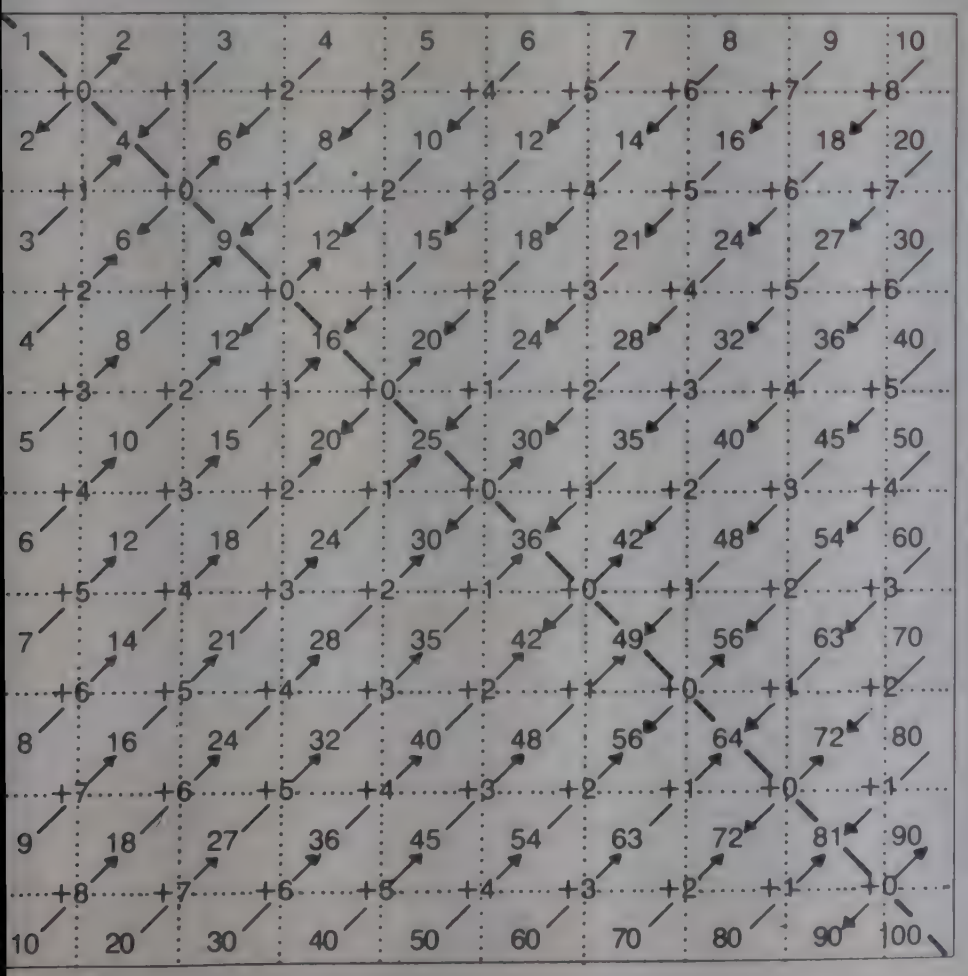
Multiplication table by method I

Table - 3

1	2	3	4	5	6	7	8	9	10
2	4	6	8	10	12	14	16	18	20
3	6	9	12	15	18	21	24	27	30
4	8	12	16	20	24	28	32	36	40
5	10	15	20	25	30	35	40	45	50
6	12	18	24	30	36	42	48	54	60
7	14	21	28	35	42	49	56	63	70
8	16	24	32	40	48	56	64	72	80
9	18	27	36	45	54	63	72	81	90
10	20	30	40	50	60	70	80	90	100

A wonderful pattern in the multiplication table

Table - 2



Multiplication table by method II

Table - 4

1	2	3	4	5	6	7	8	9	10
2	4	6	8	10	12	14	16	18	20
3	6	9	12	15	18	21	24	27	30
4	8	12	16	20	24	28	32	36	40
5	10	15	20	25	30	35	40	45	50
6	12	18	24	30	36	42	48	54	60
7	14	21	28	35	42	49	56	63	70
8	16	24	32	40	48	56	64	72	80
9	18	27	36	45	54	63	72	81	90
10	20	30	40	50	60	70	80	90	100

A pattern which generates peculiar sums

Can you find out the pattern each of these tables projects. (Check your formulae with the formulae given at the end.)

Table 1 displays the rules,

$n + (n + 2) = 2 (n + 1)$

$n + (n + 2) + (n+ 4) = 3 (n + 2)$

$n + (n + 2) + (n + 4) + (n + 6) = 4(n+ 3)$

and so on.

Table 2 displays the rules,

$n(n + 1) + 2 (n + 1) = (n + 1) (n + 2)$

$n(n + 2) + [2(n + 1) + 1] = (n + 1) (n + 3)$

and so on.

Table 3 displays the rules,

$n + (n + 2) = 2(n + 1)$

$2n + [2(n + 2)] = 4(n + 1)$

$3n + [3(n + 2)] = 6(n + 1)$ and so on.

Table 4 displays patterns of 20 cells each, selected in a particular format. You will find that the sum of the values in these 20 cells will always have five in its units place.

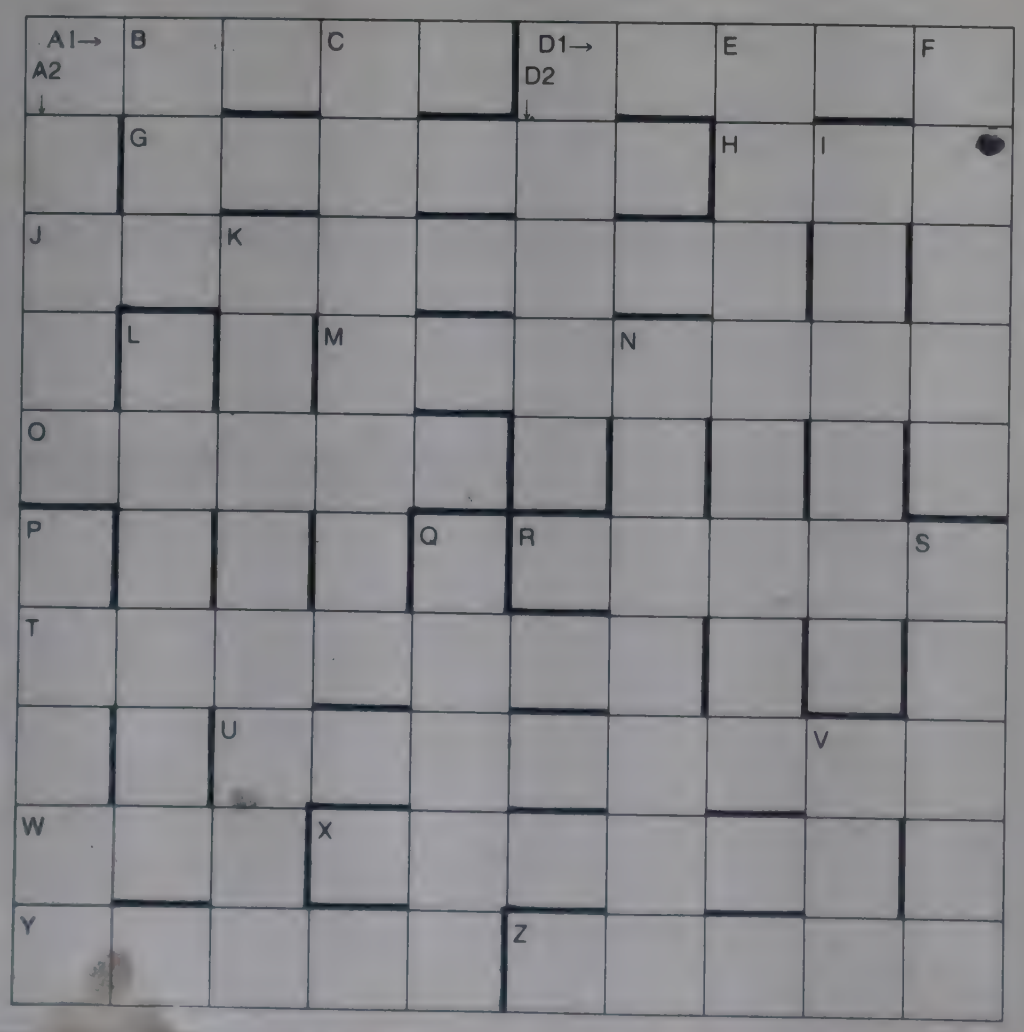
VIDYA N WADADEKAR

Mrs Wadadekar, senior research assistant at the Institute of Banking, was formerly research fellow at the Homi Bhabha Centre for Science Education at Tata Institute of Fundamental Research.

CROSS NUMBER

All numbers are in binary notation. The usual rules for writing binary numbers apply.

A1 A composite number
A2 F + B
B A factor of A1
C A composite number
D1 P − V
D2 A composite number
E A prime
F K − E
G E − U
H A factor of R
I A prime factor of C
J A composite number
K E + F
L A composite number
M LCM of D2 and L
N A composite number
O H + √J
P D1 + V
Q A factor of U
R A composite number
S A factor of N
T A palindromic number
U E − G
V Square root of Z
W A factor of A1
X A composite number
Y HCF of T and X
Z A composite number



TEASER

A FRIEND of mine appeared for an interview for a chief chemist's post in a government laboratory. Gandhi, Khanna and Mehra, who were also my friends, were the experts in the selection committee, each with a veto power (the selection had to be unanimous). My friend wasn't selected, since one of the experts used his veto against the candidate. Later I met all of them at a party. On casually enquiring about the fate of the candidate in the interview, they made the following statements:

Gandhi: 1 Everything Khanna says is true.
2 Everything Mehra says is true.
3 I didn't use my veto against the candidate.

Khanna: 1 Everything Gandhi says is false.
2 Everything Mehra says is false.
3 I didn't use my veto power against the candidate.

Mehra : 1 Gandhi did use his veto against the candidate.
2 Khanna did use his veto against the candidate.
3 I thought more about your candidate before the interview than is generally realized.

I found that Gandhi and Khanna had made the same number (0 — 3) of true statements. Who used his veto?

Solution to last month's teaser

For Doshi's prediction to be correct he should be the teacher, but he had predicted that Charlie would be the teacher. Hence neither was the teacher. So Charlie's prediction was also wrong. Hence Ahmed is the doctor. So Bhat is the teacher and his prediction must be true, that is, Doshi is not an engineer, leaving Charlie to be the engineer and Doshi, the politician. The whole set up is : Ahmed — doctor; Bhat — teacher; Charlie — engineer; and Doshi — politician and Ahmed's prediction was wrong Hence Meena Kumari did not get the Filmfare Award that year.

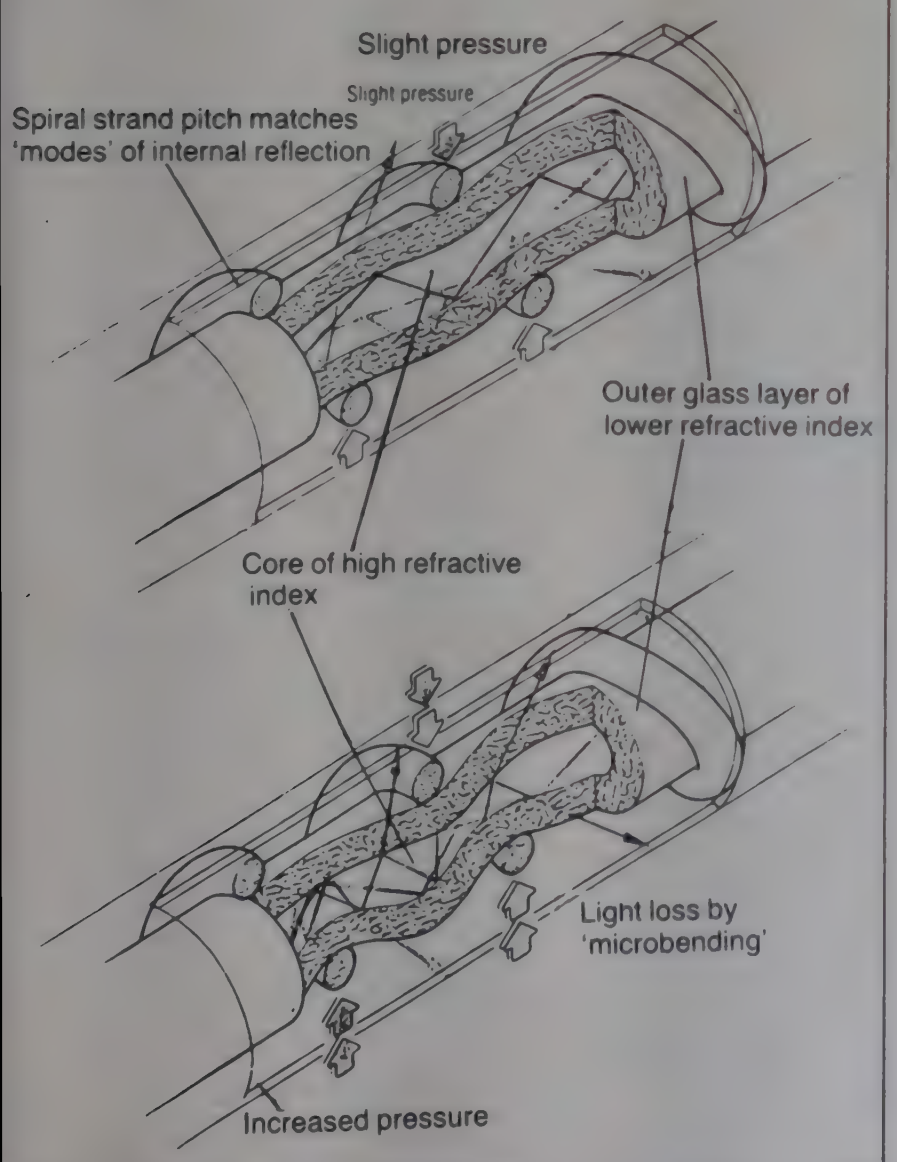
V A SHENAI

Breakthrough in fibre-optics

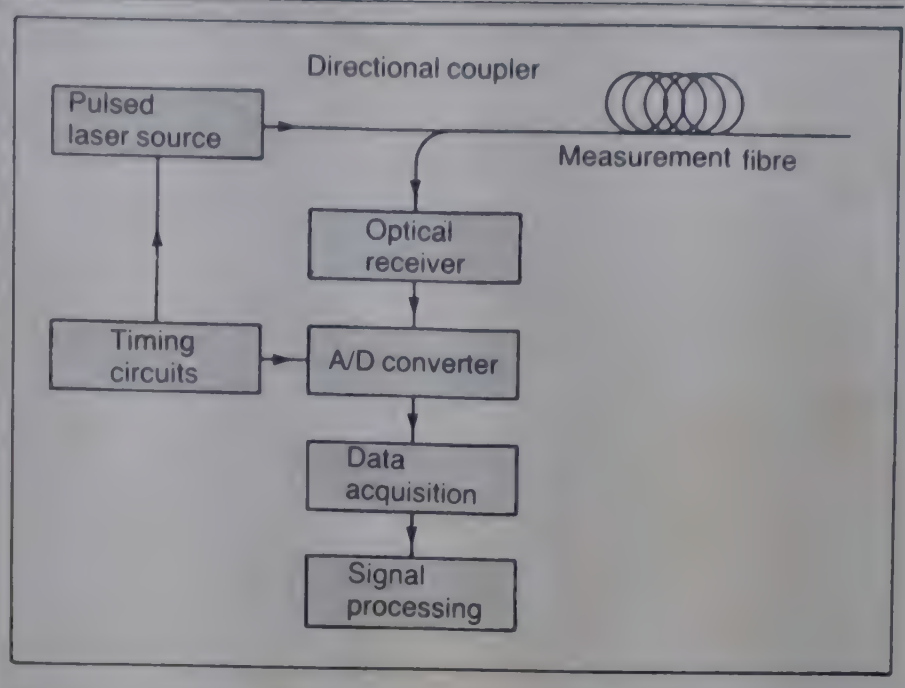
THREE MAJOR advances have been registered in fibre optics, making it cost-effective for shorter distances in telecommunications. They will also extend the range of industrial lasers from machining and finishing operations to precision measurements. Of course, it has already been clearly established that both the US and Japan have been using British Telecom's fibre-optic technology — coherent fibre-optic systems — resulting in substantial improvements in long-distance telecommunications, making for higher transmission speeds and yet needing fewer repeater stations to boost the signals.

Cheaper coherent transmission systems used to be otherwise more sophisticated as they used to require a pair of sophisticated laser sources that emit light within a very narrow frequency range. The laser output must be limited to a range of about one million hertz (megahertz) while the laser frequency is some 300 trillion hertz (tetrahertz). The difference between laser and local oscillator frequencies also must remain constant. US researchers had reported that by using or adapting British Telecom's active stabilization circuit it was possible to keep the frequency of the local-oscillator laser exactly 950 megahertz or 1.7 gigahertz away from that of the signal laser.

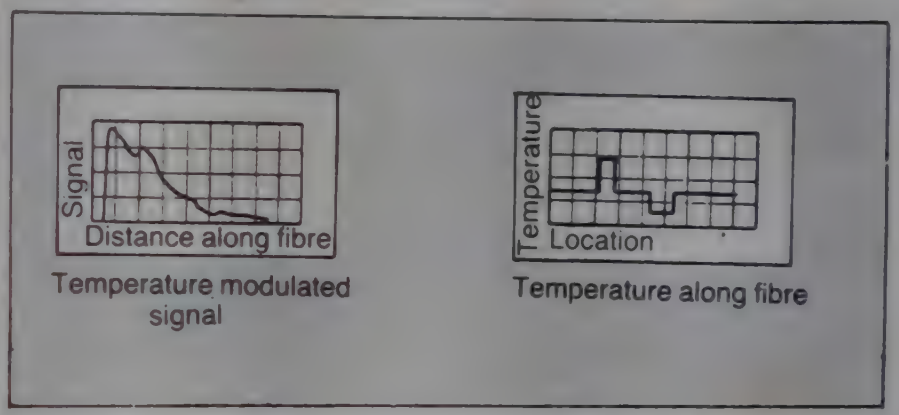
The British Telecom's researchers had argued that coherent detection was more sensitive, and thus more subtle, because it relied on the heterodyne principle used in sensitive radio receivers.The light system emerging from the fibre is mixed with a light from a local oscillator at the receiver, producing a "best" which can be detected and amplified electronically. In practice, both light sources are semiconductor lasers, and the intermediate frequency of the beat mixing the two laser outputs is in the gigahertz range. In theory, coherent fibre-optic systems should be able to detect signals 30 to 100 times fainter than direct detection. This potential allows transmission through tens of kilometres more optic fibres before requiring a repeater to boost the signal.


Slight pressure
Slight pressure
Spiral strand pitch matches 'modes' of internal reflection
Outer glass layer of lower refractive index
Core of high refractive index
Light loss by 'microbending'
Increased pressure

The principle of Optical Time Domain Reflectometry (OTDR)



Winding a spiral around an optical fibre at a pitch which corresponds to the main modes of internal reflection of light within the fibre allows it to operate as a sensitive contact sensor



The second major breakthrough has been registered by an American commercial firm specializing in fibre-optics, which is being called a monomode form of optical fibres. The main advantage claimed by the monomode fibres is that it enables relatively simple lasers to be used rather than complex single frequency lasers. This has now made larger cost reductions possible, and consequently has made fibre-optics very attractive for short-haul telecommunication routes. The new optical links are expected to carry not only error-free transmission, but also four times as many calls as their copper wire equivalents, and most of the links operate end-to-end with no intermediate boosting of signals required.

Finally, optical fibres have made the industrial uses of lasers much easier, and certainly more cost-effective. Lasers are now well-established in industry for cutting, heat-treating and welding. Directing the light from these devices to the work-piece is usually done by mounting the laser or a conventional XY table. For less powerful lasers beam guidance can now be undertaken by optical fibres.

By far the biggest area of application of optical fibres is in telecommunications, but more recently the use of lasers and optical fibres for industrial sensing has been intensively studied. Light has two principal advantages over electricity for signalling and sensing. It is interference-free, and safer for use in explosive or flammable atmospheres. Pressure and temperature are now monitored by two recently developed fibre-optic sensors.

The first of these sensors is expected to find applications in

contact sensing bumpers for automated guided vehicles and in safety systems interlocked with robot arms. In this device applied pressure causes "microbending" of an optical fibre which results in large losses of light from the core of the fibre into its cladding. These changes in the light levels are detected, and a signal is sent to the main control of the machinery being protected.

The sensing element in this device is flexible and can be formed round corners to a radius as small as 25 mm. Since the light never leaves the system, the sensing element remains unaffected by dirt, dust, or vibration. Using other materials to construct the spiral could result in variable response rates. Continuing development of the intrinsic sensor has revealed many potential applications including flow measuring devices, level gauges, and accelerometers.

Temperature is another important parameter in many industrial processes, and, in many factories, needs to be accurately measured at several hundred points, by many temperature sensors. This can become an expensive operation and the information received is easily distorted, even corrupted. A single length of optical fibre, installed along the path of monitoring exercise is being utilized in the process control and power supply industries. The system makes use of optical time domain reflectometry (OTDR), a form of optical radar used to analyze faults in telecommunications' fibres.

Light from a pulsed laser is injected into a monomode optical fibre through a directional coupler. Direction along the length of the fibre cause reflected signals which are received back at the instrument and directed to a receiver. The received signals are processed and then may be displayed against a time base — on an oscilloscope or a plotter — so that any temperature differential along the length of the fibre can be pinpointed. In order to use OTDR as a sensing technique, it is necessary to make the amplitude of the local back-scattered signal respond in accordance with the temperature variation to be measured.

These three major innovative advances in the use of optical fibres have become possible recently. It is their versatility that has put them to normal commercial and industrial uses. Originally, fibre-optics was being developed as high speed, error-free system utilizable in telecommunications, but later, developers of optical computers, Japanese and the US R & D researchers, found their uses in several optico-electronic systems too — something that brought a practical realization of conceptions of optical computers.

World's first wave-powered station

EVER SINCE a search for viable alternative and renewable sources of energy started in early 1970s, small power stations based on wave energy had been planned. The first batch of R & D projects in the utilization of energy of sea waves was related to wave velocity surveys. These surveys, in different countries including India, posed certain technical snags and bottlenecks in commercial utilization of wave energy. But it became clearer that Northern European countries presented ideal locations for wave-powered stations, though only very small in magnitudes, say from 850 kilowatt to 1000 kilowatts.

The world's first wave-powered station was switched on in Norway towards the end of 1985. It consists of two types of wave-powered units, which together generate 850 kW. The new station is connected to a small, local electricity energy grid. Despite its small size, the wave-powered station generates electrical energy cheaper by 4 pence per kilowatt (7.2 paise) as compared to coal-fired new power stations being put up in the UK by Britain's Central Electricity Generating Board; its capital cost per kilowatt of power generating capacity has also turned out to be lower than fossil-fuel-based new power stations.

One of the generators installed in Norway was developed from the work by Alan Wells at Queens University (Belfast). This unit is an enclosed steel cannister, known as a multi-resonant oscillating water column, which looks like a large boiler. Both the top and the bottom of the unit are open. When the waves rise inside, they force air upwards so that it turns the turbine blades. When the water unit sinks, air is sucked downwards, again turning the blades. The main bottleneck faced by engineers of this unit was to design the blades to turn in the same direction, whichever way the wind blows.

The other wave-powered unit is very different. It consists of a reservoir about three metres above sea — and a 90-metre tapered channel to the sea. The energy from the waves forces water up the tapered channel to the reservoir, and makes water overflow from the reservoir. The overflowing water falls down over turbine blades, turning them to generate electricity.

The turbine blades are made from nickel and bronze to protect them from corrosion by the salt in the sea water; these could have also been fabricated from carbon fibres, though currently carbon fibres turn out to be more expensive than nickel-based steel alloys. So far, this is the first wave-powered station, but viewing its smooth running, some more units are being planned on the coasts of other countries.

In India, wave-powered stations can also be put up as both in the Bay of Bengal, as well as the Gulf of Cambay areas on the coasts of Gujarat, there are sites where such stations could generate electricity, especially after seeing the smooth and commercially viable generation of power from waves.

Use of fungus in clearing pollutants

ENVIRONMENTAL POLLUTION is assuming worrying proportions. Several R & D teams throughout the world are trying to search and deal effectively with it with cost-effective agents. An American team's work published in *Science* is considered a major breakthrough in the high technology field..

Microbes which normally help the breakdown and recycling of chemical substances are ill-equipped to neutralize those man-made poisonous pollutants such as dioxin and DDT. The upshot is that the dangerous effects of these pollutants are compounded by resistance to natural degradation.

The American R & D team has discovered a fungus that is able to overcome that resistance and hopes that its discovery might one day be set to work cleaning up pollution. The fungus, *Phanerochaete chrysosporium*, otherwise known as a white-rot fungus, normally attacks wood.

The main component that makes trees rigid is a complex polymer called lignin, which relatively few organisms are capable of degrading chemically. When the white-rot fungus experiences a shortage of nitrogen, it secretes an enzyme that is capable of digesting lignin into smaller molecules, which are degraded into end-products such as carbon dioxide. It is those formidable chemical powers that give the white-rot fungus its versatility to degrade dioxin, DDT, even polychlorinated biphenyls (PCBs) and lindane.

The research team had established the reaction mechanisms of these degrading reactions by the use of radioactive carbon. The team also studied the detailed timings of actions initiated by the white-rot fungus — of which there are nearly 1,600 varieties — to choose right type for the pollution cleaning jobs. The wide variety of fungus also makes it more acceptable to choose the ones which are cost-effective.

O P ARYA

Technological progress under the microscope

TWO RECENT developments in scanning microscopy will enable scientists to study live microscopic biological samples in the near future.

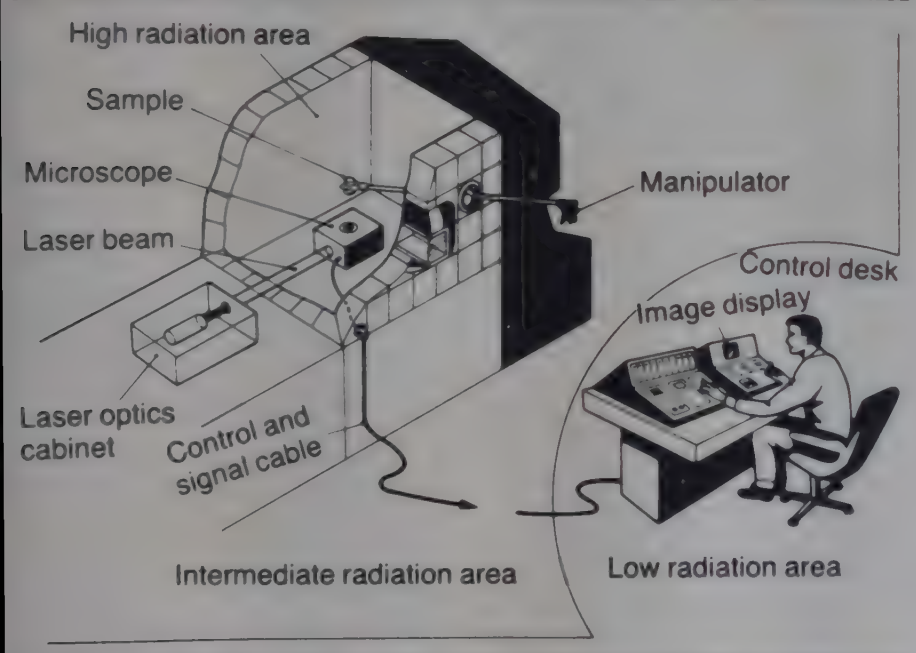
One uses X-rays and is specifically designed to study live tissue, cells and large molecules. The other uses the laser and is designed as a remote controlled instrument for the examination of radioactive samples. The latter's potential for studying live microscopic life forms stems from its long sample-to-lens distance and low level of heat exposure.

Although not the first to utilize X-rays for microscopy, Professors Philip Duke and Ronald Burge of King's College, London have been able to extend this application of X-rays because of their breakthrough in the method of manufacturing an essential optical element, called a Fresnel zone plate, capable of focusing X-rays.

Zone plates are circular optical plates on which are etched concentric lines. The lines grow progressively narrower and are placed closer together the further they are from the centre of the plate. The lines block the paths of the X-rays while the zones between the lines allow the X-rays to pass through. The X-ray waves that pass through the plate fan out beyond it to produce a wave pattern — crests and troughs adding together or cancelling each other out — that focuses at a single point.

The resolution of the zone plate depends on the distance between the outermost zones, and the ideal distance is equal to one wavelength. Prior to the work at King's College, the best zone plate in use was capable of resolving objects down to 0.25 micrometre which is 2500 angstroms. The technique developed by Duke and Burge, however, can produce zone plates with a resolution of 800 angstroms, and it is possible that plates with 100 angstrom resolution will be made in the near future.

Their technique, ironically, uses the electron microscope — the instrument that cannot be used for the study of living tissue because it has to operate within a vacuum. The beam of an electron microscope is projected on a glass plate on which it deposits, by precipitation, the carbon from the hydrocarbon impurities found in even the best vacuums. Such precipitation is normal in electron microscopes. By controlling and guiding the beam, the researchers are able to manufacture a zone plate with 800 angstrom resolution by creating rings of carbon particles.



There are two types of X-ray microscope — imaging and scanning. The latter has a micro-focused spot of X-rays, which are produced from a synchroton source in highly concentrated and directional bursts almost at the speed of light. These scan a moving sample while detectors pick up the transmitted rays.

The scanning system uses X-rays more efficiently than the imaging type, while radiation damage to the sample is minimized. In addition, the scanning method provides data that can be digitized, and so is suitable for computer use, and is less sensitive to focusing aberrations.

The ability to micro-focus the X-rays leads to other benefits, such as the provision of three dimensional images. This is possible because X-rays, unlike the electrons of an electron microscope, which barely go beyond the surface, penetrate the sample. While scanning the variation in beam intensity of the X-rays at different levels in the sample from another plane, a cross-section of the sample can be produced by a computer, as in computerized tomography.

The new developmen will do more than provide the opportunity to study microscopic life forms. It will also become possible to identify the distribution of a given element in the living system because each element absorbs X-rays of a specific wavelength. And with X-ray fluorescence scientists will be able to study the chemical environment of atoms.

The main purpose behind the development of the scanning laser microscope, at the United Kingdom Atomic Energy Authority's Windscale Nuclear Power Development Laboratories, is to provide a remotely controlled and inexpensive instrument to replace existing high quality optical microscopes, which require extensive and expensive modification.

The work for which the microscope is required at Windscale is the examination of irradiated samples of fuel, cladding and reactor components. The samples are prepared on standard metalographic mounts, polished and acid etched. Examination of optical microscope takes place in a lead cell enclosure, constructed so as to protect the operator from radioactivity. It is this provision of protection, and the associated modification to the original microscope, that boosts the initial cost by 500 per cent.

The new instrument works by scanning a focused, low power beam over a prepared sample. The scanning, in two dimensions — X and Y — is carried out by a single point detector. The optical image is converted to a digit data stream, making the output from the instrument suitable for input to a computer, or to a data storage unit.

A single point detector scanning in two dimensions was chosen because the system maximises image resolution. This stems from the fact that the usual intermediate step of using an objective lens to produce a two dimensional image is eliminated, and the associated lens aberrations are absent. Image accuracy is determined by how accurately the position of the focused laser spot is measured.

The laser microscope is in two sections. The optics are mounted inside a cabinet, and give an output in the form of a parallel beam of light. The scanning stage, which can be up to 10 m from the optics cabinet, is aligned to receive the parallel beam.

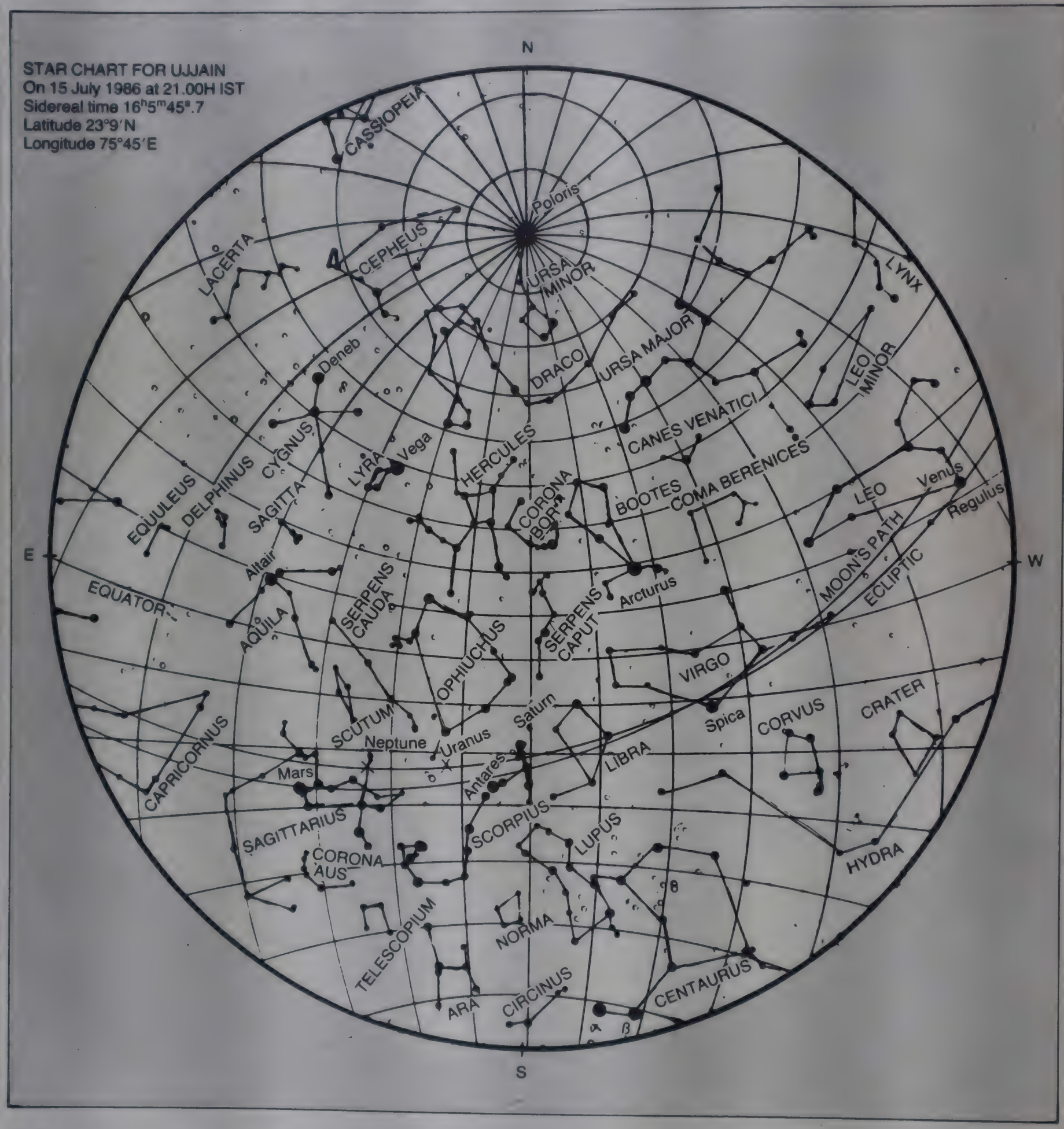
The laser beam is passed through a beam expander to produce the parallel beam of light. This is focused to a small spot by a lens mounted at the end of a scanning arm. As the lens is scanned across the sample, different areas of the beam are focused to produce a scanning spot. The rays reflected from the sample retrace the same path back through the lens and are turned through 90 degrees by a beam splitter, passing through another lens and on to a photodiode.

The scanner arm is attached to a torsion bar which is made to vibrate close to its natural frequency of 200 Hz. The oscillations are sustained by electromagnets. Simultaneously, the slide on which the sample is mounted is oscillated in a direction perpendicular to the lens movement (the Y direction). The position of the scanner arm is measured by sensors in the X direction and by a displacement transducer in the Y direction.

Unlike conventional microscopes, the scanning laser microscope allows continuous adjustment of the magnification, so that it is possible to zoom in on a feature of interest. Another big advantage is that, since a single objective lens is used, less time is wasted in lens changing and coarse focusing adjustments are unnecessary.

The new microscope meets all the design requirements, including a 67 per cent reduction in costs. At 1984 prices, the microscope costs £15,000 whether it is of the optical or laser type, but the optical version requires £20,000 for modification. Added to this are installation costs of £15,000 for the modified optical unit.

The sky in July-August 1986

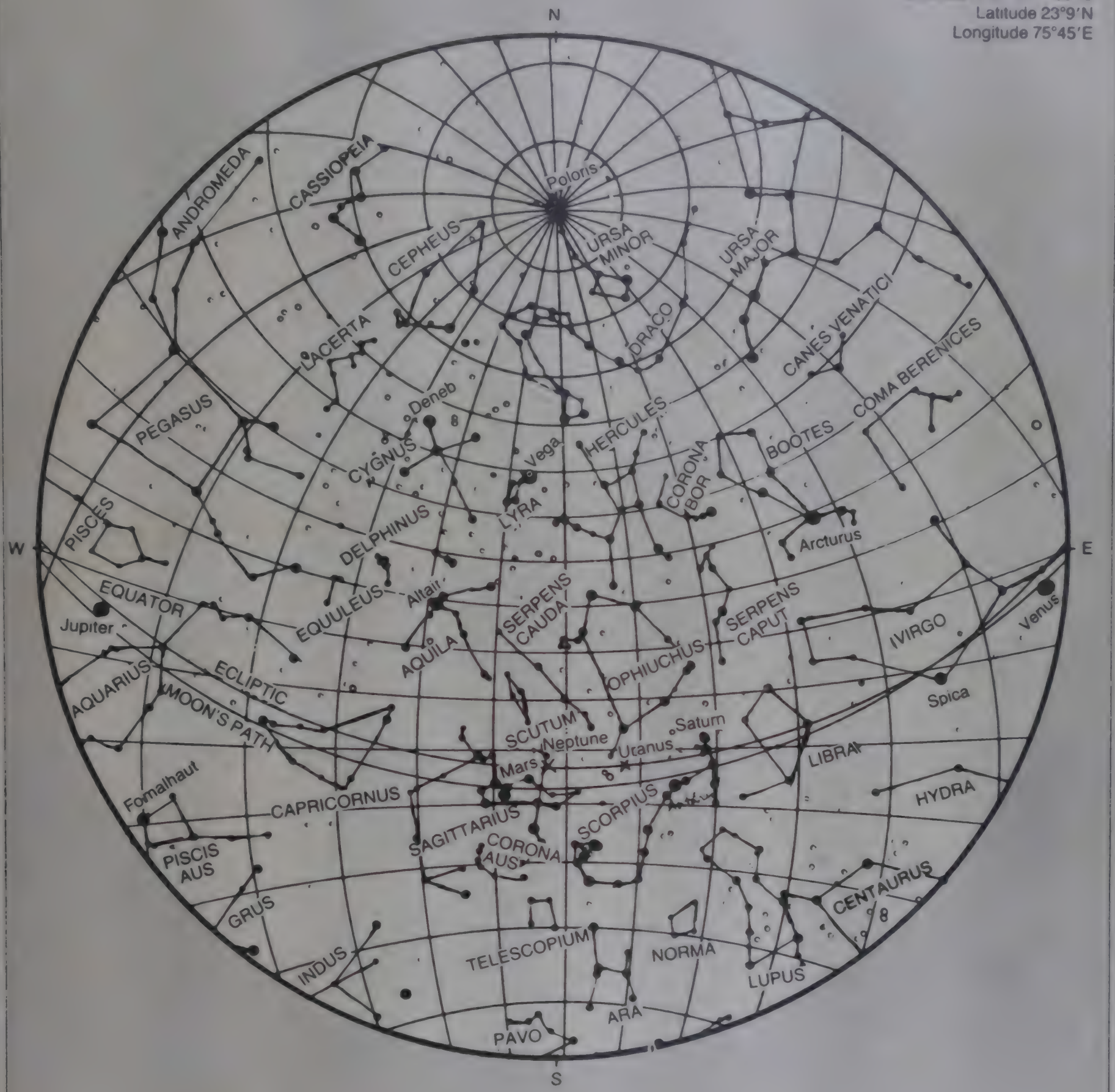


MARS COMES closest to the Earth once every two years.

The adjacent star charts are given for Ujjain (23°15′N, 75°45′E) for 21.00 IST on 15 July and 15 August respectively. During these monsoon months, the central part of the Milky Way is seen in the evening sky and one really does miss the splendour of it. In the early part of July, one can even see both the Crosses in the sky — the Northern Cross (Cygnus) appearing on the north-east and the Southern Cross setting in the south.

During the first week of July, Mercury is seen in the evening sky somewhat below the constellation Leo. It reappears in the morning sky in the first week of August and continues to be seen with the naked eye for about two weeks.

This year the Moon's path runs very close to the star Antares in Scorpius. Almost in every transit from 30 Mar to 29 Dec the Moon's limb has to cross Antares. For an observer in India, the



most favourable day would be on the evening of 14 Aug. The Moon will also be seen to narrowly miss Mars on the evening of 20 July, but on 16 Aug Mars will be occulted by the Moon. Venus will pass by Regulus on 11 July. During the second week of July one would see in the evening sky all planets except Jupiter which will rise about four hours after sunset. Venus in the west and Mars in the east will dominate the evening sky and it will be soon joined by Jupiter by the end of August.

Mars comes to an opposition with the Sun on 10 July and due to its eccentric orbit it comes closest to the Earth on 16 July. This time Mars has come much closer to the Earth than it did last time in 1984 and it will come even closer next time in 1988. Light will take hardly 3 minutes and 22 seconds to reach us from Mars on July 16th.

N C RANA

Dr Rana is with the Theoretical Astrophysics Group, TIFR, Bombay.

THE STORY OF PHYSICS (19) - T PADMANABHAN & KEITH FRANCIS

Thomson's model of the atom kept both positive and negative charges together

Just like seeds in a water-melon.....

YAWN

J J THOMSON

E RUTHERFORD

SMOOTH DISTRIBUTION OF +VE CHARGE.

-VE CHARGES STUCK IN IT.

THOMSON'S ATOM

There must be a way of testing this

If I hit the atom with an alpha particle....

....the scattered path of the alpha particle will tell me about the atom.....

POK!

Thomson's atom would hardly deflect an alpha particle

Rutherford examined the scattering of alpha particles by metal foils

THE MADDENING DETAILS

A: Source of α particles
B: Metal foil
S: Scintillating screen
M: Microscope
R: Rotating cavity
C: Coffee

The results were sensational

EXPECTED:

SMALL DEFLECTIONS

OBSERVED:

ATOM ?

TOTAL BOUNCE

LARGE DEFLECTIONS

Question: What atomic model can produce the observed scattering? Answer:

R C FOWLER

I can calculate it theoretically, you know!

Theory? Bah!

Okay, go ahead

Good; here it is!

-ve charges in orbit

+ve charges at centre

Nice! Very nice! Just like planets

Mm..m. I don't like it all that much

N BOHR 1885-1962

ELECTRON

NUCLEUS

LIGHT

Since an orbiting electron must be radiating energy it will spiral to the centre

So, according to our laws, atoms can't exist!

Then let's change the laws!

To understand how Bohr "changed the laws" we've to go back a few years. Someone was already tampering with the laws!

E

THEORY

OBSERVED

f

Our laws can't explain radiation in a cavity. Let me change it

M PLANCK 1858-1947

"Radiant energy can be absorbed or emitted only in quantized units"

Planck introduced a new constant

Energy of a quantum = h x frequency

h = 6·6 x 10^{-27} ergs sec

Look, what really are these quanta?

Mm.... I don't know!

All the same quanta could explain many things....

Probably radiation itself is quantized

Now you see, now you don't, eh?

....Like the "photoelectric effect"

CLASSICAL THEORY: E∝ INTENSITY

QUANTUM THEORY: E∝ FREQUENCY

LIGHT

METAL

FREQUENCY f

ELECTRONS WITH ENERGY E

All this set Bohr thinking....

If radiation energy is quantized.....

....why not the energy of electrons in atoms?

When the last guests are telling you what a lovely party it was, are you worrying about all the precious glass and the silver (not to mention the fridge on which someone spilt the salad dressing) that you have to wash yourself?

Relax, now that Teepol Special Liquid Cleaner is here! It's the most effortless way to clean all the things you value so much, you don't trust anyone but yourself to wash them.

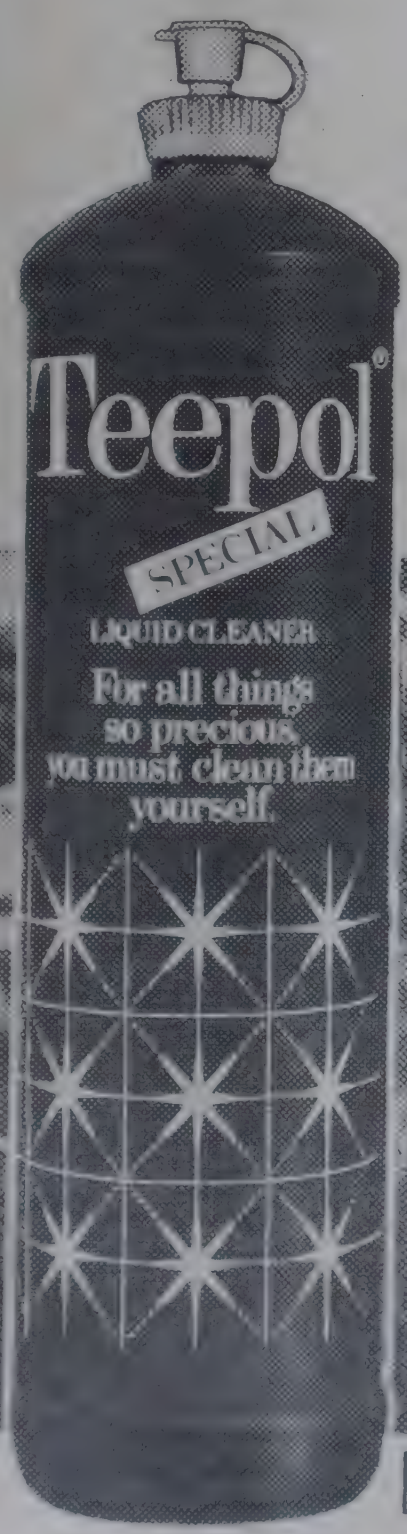
Teepol Special Liquid Cleaner is specially formulated to clean all your valuable household articles. Like crystal, glassware, crockery, cutlery, silverware, stainless steel vessels, refrigerator, mixer, blender, oven and cooking range. You'll be amazed how just a little Teepol Special washes so much, so effortlessly.

Pleasantly perfumed Teepol Special cuts through grease quickly, yet is so gentle on your hands. Leaves no scratches, no stains, nor the chalky film of washing powders. Just a never-before sparkle and sheen! Go ahead, hold a glass that you've just washed with Teepol Special against the light. Frankly it looks so clean and in such mint condition, it could pass off for new.

How to get the most out of Teepol Special:

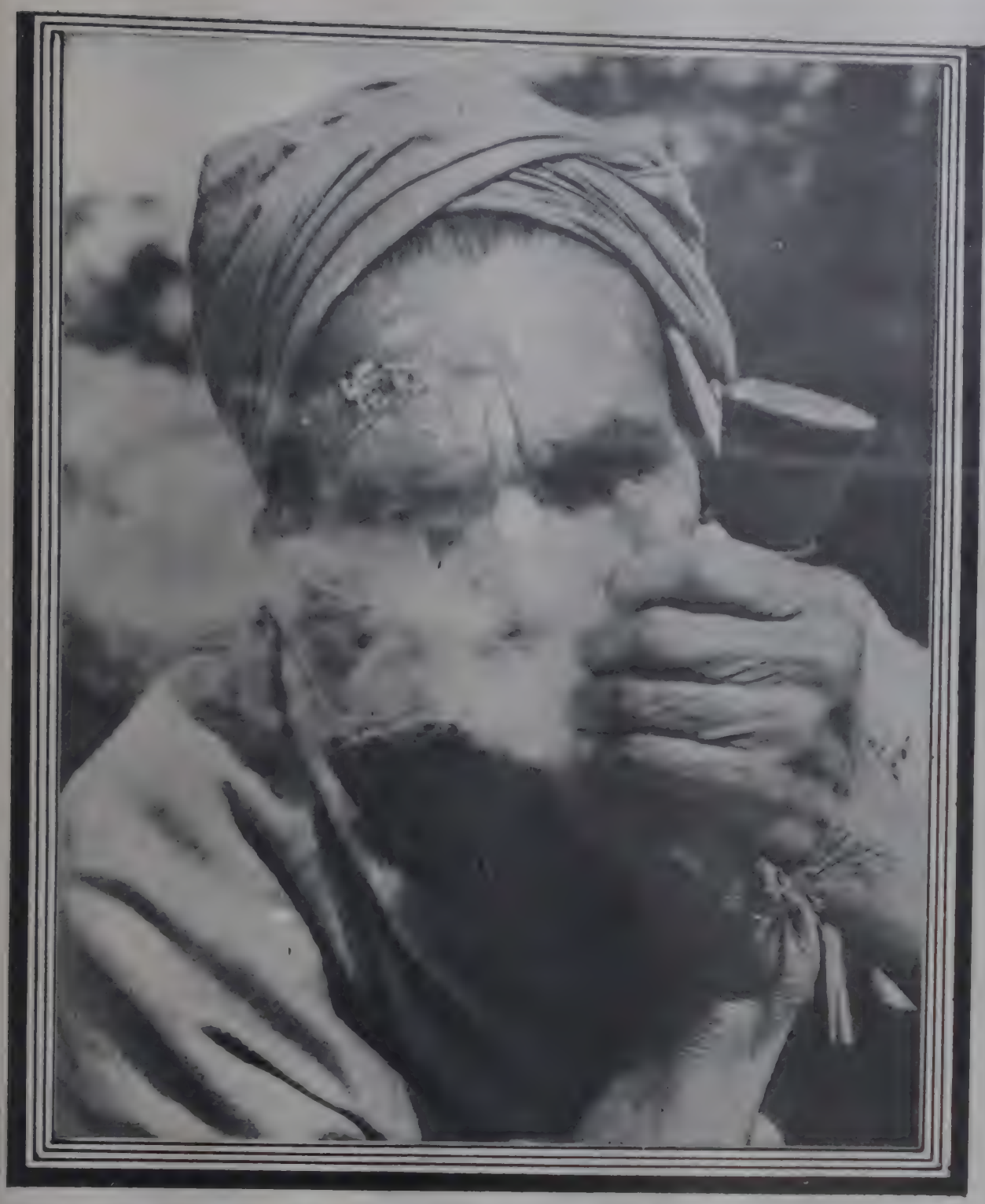
Squeeze Teepol Special in a bowl of water. Stir up a rich foamy lather. Dip sponge or cloth and wipe the article clean. Wash in clean water for a brilliant sparkle.

When you can't trust anyone else with your precious possessions — trust Teepol Special



A ... quality product

CHAITRA-B NOC 400B



Balkrishan

TOBACCO'S DEADLY REACH

WILLIAM CHANDLER

TOBACCO CAUSES more death and suffering among adults than any other toxic material in the environment. The worldwide cost in lives now approaches 2.5 million per year, almost five per cent of all deaths. Though the health consequences of tobacco are now well known, policies to avoid them lag far behind. Most efforts to control tobacco are merely attempts to control or colour information about the product.

Smoking is an epidemic growing at 2.1 per cent per year, faster than world population. Growth in tobacco use slowed briefly in the early eighties, primarily for economic reasons, but is resuming its rapid increase. Over a billion people now smoke, consuming almost five trillion cigarettes per year, an average of more than half a pack a day.

Change in tobacco use can be measured in two ways: changes in the use of tobacco products, in absolute or per capita terms, and changes in smoking prevalence. But the absolute quantity of tobacco used provides an essential measure of total health costs that a society must bear. Indeed, the total number of cigarettes smoked over a lifetime is a more important health index than cigarettes used per day at any given time. Health risks increase in proportion to total amount of tobacco used. Moreover, the quantity of cigarettes smoked, when considered along with smoker-non-smoker interaction and room ventilation rates, provides a measure of passive smoking.

In the second measure of change in use — smoking prevalence — Western nations have seen encouraging reductions during the last decade. In the United Kingdom, the percentage of males who smoke dropped by more than 25 per cent. In the Netherlands and the United States, the equivalent reductions were more than a third. And in Norway, a nation often cited as having a model tobacco policy because it completely bans advertising, a one-fifth reduction in smoking among men with some higher education has been reported, though 42 per cent of men still smoke.

In fact, rates of smoking remain quite high among men all around the world. Smoking among women, on the other hand, remains very low in many countries. Teenage girls in the United States, however, now smoke more than boys do.

One ironic result of campaigns to reduce smoking in the absence of a more general effort to control tobacco has been the marked increase in the use of "smokeless" tobacco. The use of "chew" or "snuff" in the United States has increased by over 40 per cent in the last two decades. Much of the new interest in these forms of tobacco comes from teenage boys who like the stimulus of the nicotine, perhaps feel "grown-up" when they try it, and believe that it is safer than smoking. Unfortunately, these forms of tobacco are strongly linked to oral cancer, an effect seen in India, where chewing — and oral cancer — is common.

Measuring smoking by educational level also reveals trends with important implications for policy-making. There is an inverse relationship between educational level and smoking in the United States, the Soviet Union, and elsewhere. Over 60 per cent of US adult males with only a primary education smoke, while less than 20 per cent of men with an advanced degree are smokers. This relationship appears to hold in most of Western and Eastern Europe.

The direct cost of addiction

No avoidable condition claims more adult lives than tobacco addiction. Between 2.0 million and 2.5 million smokers die worldwide each year from

heart disease, lung cancer, and emphysema — smokers' disease, as it is called — caused by their addiction. Additional thousands die in fires caused by cigarettes and from cancers caused by tobacco consumed as snuff or chew. Almost one fifth of all US deaths can be traced to cigarette smoke.

The addictiveness in any case is beyond question. British scientists A C McKennell and R K Thomas found in 1967 that only 15 per cent of teenagers who experimented with tobacco were later able to quit. W A Hunt and J D Matarazzo, have found that 75 per cent who do quit smoking start again within six months. Quitters very often "crave" tobacco, probably nicotine, even several years after quitting. There is a withdrawal period of about two weeks, however, during which unpleasant physical symptoms arise as a result, it seems, of the brain's chemical dependence on nicotine.

Withdrawal from tobacco differs from that of heroin only quantitatively, and it is satisfaction of the addiction itself that leads some smokers to believe that tobacco makes them more alert and clearer thinkers. It is more immediately rewarding than caffeine, for example, which takes almost 30 minutes to reach the brain when ingested as coffee. A "hit" of tobacco reaches the brain in 30 seconds.

Cigarette smoke contains some 4000 chemical compounds which not only attack the lungs but reach the bloodstream — where they circulate, causing or accelerating atherosclerosis (clogging of the arteries) and cancer in internal organs.

Heavy smoking can precipitate heart attacks when inhaled carbon monoxide displaces oxygen in the blood. Concentrations of up to 10 per cent carbon monoxide in blood hemoglobin can, when coupled with reduced blood flow in heart arteries as a result of atherosclerosis, starve heart muscle of oxygen and damage or destroy the heart muscle — that is, cause a heart attack. The risk is serious at any age, but it is so clearly responsible for most heart attacks in young men that some scientists have called it a disease of smokers. Fortunately, the risk diminishes rapidly in ex-smokers, approaching that of non-smokers within one year after they quit.

Smoking is also the leading cause of death from cardiovascular disease. An estimate of such deaths worldwide due to smoking cannot be reliably made, however, because of the complicating factors of diet and life-style. This constraint may lead to an underestimate of overall mortality due to tobacco use.

A related cardiovascular disease caused by smoking is arteriosclerosis of the peripheral arteries. As in heart attack and stroke, smoking accelerates or precipitates blockage of arteries. Blockages in the limbs reduce blood supply to muscles and can cause gangrene, sometimes necessitating amputation of victims' legs. Peripheral vascular disease is also an important cause of death due to blood clots moving to the heart.

Smoking carries special risks for young women. One study of women under age 50 found the risk of heart attack to be 10 times greater in women who smoked two packs per day. A Canadian study found that females who smoked heavily were 7 to 34 times more likely to have a heart attack. Significantly, it also found that women who both smoked heavily and took birth control pills were 8 to 39 times more likely than non-smokers to have heart attacks. The authors concluded that women under 35 could safely take the pill if they didn't smoke. A review of the epidemiology of heart attacks in women found that female heart attack victims die on average 19 years earlier than other women. Unfortunately, in industrial nations young women are the group whose rate of smoking is increasing fastest.

Some observers have suggested that because carbon monoxide seems to play a role both in the development of atherosclerosis and in the precipitation of heart attacks, safer cigarettes can be developed by reducing their carbon monoxide production. However, most cigarettes deliver similar levels of carbon monoxide. Worse still, low tar and nicotine cigarettes may cause many people to smoke more cigarettes to satisfy their addiction, leading to even greater carbon monoxide inhalation.

Lung cancer is predominantly a disease of smoking. Active smoking habits account for an estimated 85 per cent of lung cancer. The claims of the tobacco industry that some types of people are predisposed to lung cancer and that some unknown mechanism unrelated to smoking habits causes this condition are unlikely to prove true, because different rates of smoking in men and women over different periods of time produce different rates of lung cancer. When women in the United States did not smoke, for example, they rarely developed lung cancer. But as they took up the habit, lung cancer increased in proportion, after the lag of 20 years that it takes for cancer to develop following exposure to mutagens. In fact, in 1981 lung cancer was as prevalent as breast cancer in American women over age 55 for the first time.

Non-industrial societies with high smoking rates have high lung cancer rates; Polynesians and New Zealanders have little industry, smoke heavily, and have high rates of lung cancer. Trends such as these across varied sections of the world population also tend to implicate smoking over industrial air pollutants as the cause of lung cancer. Smoking may even explain much of the lung cancer in non-smokers. It should be noted, however, that lung cancer is a function of lifetime smoking habits, not just the use of cigarettes at one given point in time. Cancer of the bladder, pancreas, lip, mouth, esophagus, and pharynx can also be traced to the use of tobacco. Smoking causes two other serious lung diseases — bronchitis and

emphysema, referred to together as Chronic Obstructive Lung Disease.

Several nations have attempted to estimate the direct economic cost of smoking. But the cost of smoking extends beyond health care expenditures: lost income due to death and lost work due to illness, the cost of tobacco itself and the suffering borne by victims and their families.

The economic costs of smoking have generated considerable attention and controversy. Policy-makers concerned with budget deficits sometimes view the billions of dollars spent on publicly funded health care for dying smokers as an unnecessary expense. Some economists argue that these are merely financial costs that would be incurred anyway if smokers lived longer, became infirm, and needed medical care. This may be true financially, but from a benefit/cost point of view, smoking imposes unnecessary costs.

If smokers did not smoke, they would live longer and probably enjoy a better quality of life. The improvements in health are benefits in their own right, even if they do not lead to reduced health care costs. Some economists also argue that the jobs and incomes created by the tobacco business must be counted as benefits. Yet, even if other uses of land were not available, tobacco's economic costs alone would exceed its "benefits" by more than two to one.

These costs, moreover, do not include the environmental and agricultural costs of tobacco production. Tobacco curing consumes one to two per cent of all wood burned each year in Kenya and Tanzania, and one third of all wood harvested in Malawi, where harvesting far exceeds sustainable yields. Many agricultural countries, including Brazil, China, India, Pakistan, and Zimbabwe, dedicate the equivalent of between 0.5 per cent and 7.0 per cent of cropland to tobacco, with the United States and China using slightly less than one per cent in this way. Though these percentages are small relative to global resources of land and firewood, in some countries they become significant.

Assuming current trends, the already devastating cost of tobacco is certain to increase over the next few decades. Ironically, it may take the growing realization of this habit's high costs for passive smokers to actually bring about effective action. For no matter how convincing the direct costs may be to rational thinkers, smokers — being addicted — may not be able to act rationally to solve the problem of smoking.

Victims of others' smoke

Ambient tobacco smoke clearly carries a risk of cancer in non-smokers. Non-smokers are quite likely to have no choice about breathing tobacco smoke. Protecting the public from the carcinogens in passive cigarette smoke requires urgent action. Increasing the ventilation in a building appears to be impractical because it is prohibitively

The psychology of smoking

"I HAVE never smoked in my life and look forward to the time when the world will look back with amazement and disgust to a practice so unnatural and offensive. To employ idle hours men could knit as women do"–George Bernard Shaw.

Had Shaw been alive today, he would have had to recommend something other than knitting. Women seem to have left knitting for more "manly" pursuits – and these include smoking. Reports from the US show that cancer of the lung has overtaken cancer of the breast, hitherto the commonest malignancy in Western women. Among the many factors responsible are two important ones: the psychology of cigarette advertisements and the psychology of smokers.

Consider first why a tennis racquet manufacturer should pay more than a million dollars to Bjorn Borg to endorse its product? He comes on your TV set, smiles and says, "I always use Brand X Tennis Racquets." And the manufacturers rake in the profits from sales. It's a matter of identification. The consumer feels a sense of greatness and kinship with Bjorn Borg if he buys and uses the same tennis racquet. The subtle message conveyed by the ad is: "You too can improve your game and be a world-class player like Borg — provided you use Brand X and not just any tennis racquet."

Almost without exception, cigarette ads show young, virile, athletic men next to the latest model of a car – they are synonymous with money and prestige. They are sometimes surrounded by fawning, glamorous women. Or there is the loner, the rugged cowboy astride his stallion, squinting into the distance like Clint Eastwood. Once again the accent is on manliness. Some ads display men engaged in "manly" sports and pastimes: the graceful surfer, the intrepid hang-glider, the elegant golfer – all having a wonderful time, waited on by beautiful women, all of them carrying the aura of success and exclusiveness.

Now consider the psychology of smokers. In 1980, the American Psychiatric Association, introduced a "new" diagnostic category in psychiatric nomenclature. Tobacco dependence is now a recognized mental disorder.

Why do some people smoke while others abstain? Do smokers have special characteristics or personality profiles? There is no clear answer, but there are some interesting theories.

According to the followers of Sigmund Freud smokers are fixated at the oral stage of personality development. The first two years of a child's life revolves around the mouth region and presumably sucking milk gives maximum pleasure to the infant. According to Freudians, frustration or too much satiation in this oral phase leads to a preoccupation with oral things which may manifest in late life with too much eating, drinking and smoking.

Some postulate that smoking is learned behaviour. Maybe a family member who smokes serves as the model from whom smoking is learnt. Very often in response to advertisements and peer pressure, smoking is begun so as to be part of a group and have a sense of belonging. A non-smoker may be ridiculed and called a sissy by his smoker friends. Later on, through constant, repeated use, the special senses of smell and taste get conditioned to smoking.

Desmond Morris, the zoologist and observer of human behaviour, suggests that in some people, smoking serves as a displacement activity. By this he emphasises that in times of stress, which may be continuous throughout the day, the smoker uses small, seemingly irrelevant movements to mask his underlying emotional turmoil. Thus the hunt for the packet; the selection and extraction of a cigarette; tapping it to "square" the ends; the fiddling with the match-box or lighter; producing the flame; lighting the cigarette; inhaling and blowing out the smoke. Certainly there is much more than nicotine levels in the blood which is important to the smoker.

In contrast, some research workers suggest that there may be a genetic defect in the "reward centre" in the brain of people who smoke. To compensate for the defect, the brain requires an artificial boost by drugs like nicotine.

LALIT GUPTA

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expensive. Reducing the risk of cancer due to cigarette smoke would require replacing the volume of air in the living space about 250 times more often than is currently the norm — and use, therefore, 250 times the heating, cooling, and pumping. The only certain way to make indoor air safe from cigarettes is to eliminate the source.

Passive smoking has been correlated with lung cancer in non-smoking spouses of smokers in more than 10 studies. One particularly important study was derived from other research designed to track lung cancer in smokers in Japan. This work lent itself to a consideration of passive smoking because careful records were kept of spousal smoking habits. Wives who did not smoke but who lived with heavy smokers were found to be almost twice as likely to die of lung cancer as wives of men who did not smoke.

Effects on children

Tobacco's effects on children — beginning with exposure before they are born — deserve special attention. Passive smoking places unborn children at serious risk. Nicotine, numerous toxic chemicals, and radioactive polonium may all interfere with fetal development, and the fetus can receive these substances through the mother's blood whether she smokes or chews tobacco.

Research has found a strong, inverse relationship between birth weight and levels of cigarette residue (thiocyanate) in infants' umbilical cords. Low birth weight has also been associated with tobacco chewing in India. (Thirty-nine per cent of women in India chew tobacco.) Because birth weight is a key factor in infant mortality, tobacco use seriously endangers infants' lives.

Nicotine also may be the culprit in spontaneous abortions among women who smoke. Epidemiologist R T Ravenholt estimates that smoking causes 50,000 miscarriages in the United States each year.

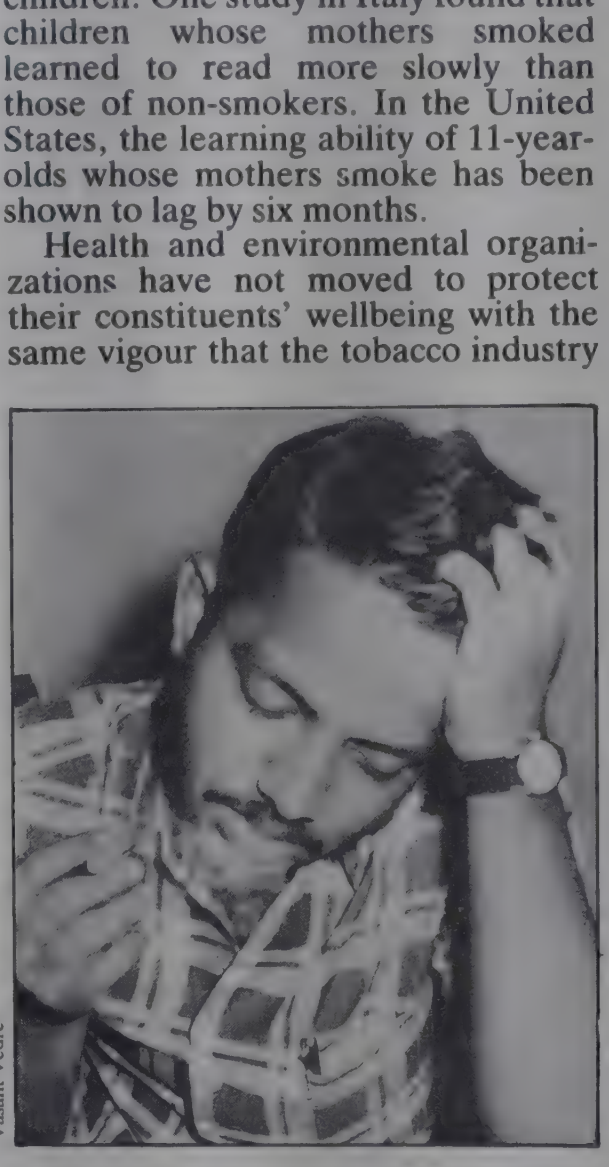
Unfortunately, women in many countries are smoking in record numbers, even while pregnant. Surveys in the UK suggest that about 40 per cent of pregnant women smoke.

Each year, at least three million newborn — the estimated number of live births to women who smoke — are thus potentially handicapped by their mothers.

Children with parents who smoke experience much higher rates of respiratory illness, including colds, influenza, bronchitis, asthma, and pneumonia. In addition, the evidence indicates that parental smoking retards child development. One study found that lung capacity in boys was reduced by seven per cent by their mothers' smoking. If the teenage boys also smoked, their lung capacity was reduced by 25 per cent. The effect of passive smoking in children can last a lifetime because it delays physical and intellectual development, and because the longer people are exposed to carcinogens, the more likely they are to develop lung cancer.

Parents who smoke may also reduce the intellectual development of their children. One study in Italy found that children whose mothers smoked learned to read more slowly than those of non-smokers. In the United States, the learning ability of 11-year-olds whose mothers smoke has been shown to lag by six months.

Health and environmental organizations have not moved to protect their constituents' wellbeing with the same vigour that the tobacco industry



Vasant Vedre

protects its pecuniary interests. Nor have governments assumed their traditional role in protecting public health by acting decisively to reduce tobacco's threat. They move swiftly to remove from the market unsafe medicines. They conduct paramilitary operations to destroy fields of marijuana or opium, but not tobacco, a far deadlier crop. They pay for expensive clean-up operations to remove toxic chemicals from the human environment. But not only do they fail to take these actions for tobacco, which is often more deadly to both users and innocent — or passive — victims, they even support efforts to stabilize the tobacco industry. This sad state of affairs is possible both because the tobacco industry itself is so strong and because the opposition to tobacco is so weak. Health advocates in general have not insisted that governments take appropriate action. They have relied instead on informational programmes alone to solve the problem.

Many people assume it is enough to warn tobacco users, through the media and with labels on tobacco products, of the risks they take and then leave to them the responsibility for their own health. They argue that if users choose to take tobacco's risk, in return for the pleasure or stimulation that it provides, that is their prerogative. To some extent this is true. But the independence and voluntary nature of this choice can be called into question on three counts.

- First, tobacco is strongly addictive. Smokers rapidly become dependent on nicotine, and then smoke to satisfy their addiction.
- Second, smoke harms more than just the smoker.
- Third, when governments act inconsistently in their management of tobacco with respect to other dangerous products that they ban, they confuse tobacco users. Asbestos, heroin, and DDT are banned to protect public health; tobacco is not. This implicitly signals that those responsible for health consider tobacco to be different, and as normal to use. Thus, teenagers can be forgiven for not taking seriously a tiny health warning on shiny new packs of cigarettes. The problem is, of course, made worse when governments actively encourage the production of tobacco.

The point at which society decides to take action on dangerous products is sometimes arbitrary. Most US federal regulatory agencies draw this arbitrary line at a level of risk of one death in 100,000 or, alternatively, one in a million people over a lifetime of exposure. The risks from passive smoking probably exceed this by a factor of 250. Active smoking, of course, exceeds the lower level by 100,000 because it causes cancer in one in 10 — some would say one in five — users. Thus, forbidding the sale of tobacco would be consistent with the prohibition of the sale of addictive drugs that harm the user and others. Banning tobacco would also be consistent with the control of strong carcinogens with very high risk factors.

Societies urgently need to examine how to better control tobacco use, for the current strategy of informational campaigns is not working well. The basis of anti-tobacco action since the mid-sixties has been information aimed at educating smokers about their health risks and discouraging non-smokers from starting.

A dozen countries have had strong anti-smoking measures — by today's

tandards — but have experienced trong growth in tobacco use. Tobacco dvertising is prohibited in Poland and estrictions are placed on smoking in ublic, yet that nation ranks among he highest in per capita cigarette consumption in the world. Advertising ans and other anti-smoking policies ist in China, East Germany and the Soviet Union, but smoking nevertheess continues at very high levels, at east among men.

Finland, Norway, and Sweden, in contrast, have imposed advertising ans and required strong warning on obacco labels, and they have experienced better results. Norway's anti-smoking policy is exceeded in strength by only four other countries, and tobacco consumption has declined by 15 per cent since the imposition of that policy. (This decline takes into account the large use of roll-your-own tobacco in that country.) Sweden's policy has been somewhat weaker than those of other Scandinavian countries, but consumption is down some three per cent since 1974, about the time its policy was initiated.

Bulgaria, Hungary and the Soviet Union have the strongest policies in the world. Bulgarians now smoke two per cent fewer cigarettes than 10 years ago, while the Soviets and the Hungarians use eight and four per cent more, respectively.

Countries with weaker policies but better results include Belgium, the Netherlands, and the United Kingdom. These governments permit advertising in print but forbid it on electronic media. They have negotiated voluntary warnings on tobacco products with the tobacco industry. Perhaps most importantly, they have conducted vigorous anti-smoking education campaigns. Cigarette consumption has declined 20 per cent or more over the last 10 years in these nations. The per capita consumption level in each is below the average for industrial countries, though well above the mean for the world. Only in the United Kingdom, however, is consumption lower than 20 years ago.

Some countries have had dramatic declines in cigarette consumption without even trying. Drops in consumption of seven to 32 per cent in Bolivia, Chile, and Zaire can be attributed to their economic difficulties. Their anti-smoking policies are among the weakest in the world.

Changes in income affect tobacco consumption, though the strength of the income effect depends on a country's stage of development. A statistical analysis of 29 industrial and developing countries suggested that, overall, cigarette consumption increases about three per cent for every 10 per cent rise in income. This relation does not apparently hold for industrial countries, however. Consumption seems more related to price and social attractiveness.

Stronger medicine

Health advocates have generally dismissed stronger medicine for dealing with smoking and tobacco. The UK Royal College of Physicians, for example, the first governmental body in the world to launch a campaign to save the health of smokers, has conceded that banning tobacco is impractical. The physicians compared such a moe to prohibition, and expressed fear that it not only would be unenforceable, but would lead to criminality. Yet, there are a few effective ways to strengthen tobacco control policies without an outright ban.

The policy questions are how to prevent the young and the naive from beginning to smoke, how to persuade smokers to quit, and how to protect the health of passive or involuntary smokers in the interim. Psychology and medicine currently do not know much about how to help these addicts, other than to recommend that they quit cold turkey.

Smoking in India

INDIA IS the third largest producer of tobacco in the world and uses it in several ways. Of the 250 million kg of tobacco per year cleared for local consumption, 78 per cent is smoked, 20 per cent is chewed, and a small proportion – about 2 per cent – is made into snuff.

Various forms of smoking are practised in different parts of the country. The most common is the bidi.

The second most common is the cheroot, or chutta. It is often smoked with the burning end inside the mouth.

The chillum, a conical clay pipe about 10 cm long, with a pebble near the mouthpiece to keep the tobacco from falling out, is the third type. A wet cloth is wrapped around the smoking end to act as a filter and to reduce heat.

In the hookah a small amount of tobacco, seasoned with molasses and at times with narcotics, is placed in a bowl and topped with pieces of burning charcoal. The smoke is passed through water which acts as a filter.

The form the smoking takes depends on the area. In the north, the chillum and hookah are common. In the southeast, it is the chutta. The bidi is most common in the western region. Among some religious groups, like the Sikhs and the Parsees, smoking is forbidden.

As early as 1955, it was shown that bidi smoking was associated with cancers of oral cavity, pharynx and oesophagus.

The table below gives the relative risk estimates for smokers and chewers as compared to a referrant group of nonsmoker-nonchewer.

Cheroot or Chutta

Hookah

Referrant Group:	Nonsmoker—nonchewer			&	Nonsmoker	
Site	Smoking only	Chewing only	Smoking Chewing		Bidi smoker	Cigarette smoker
Oral cavity	2.8*	6.0*	10.1*		2.3*	0.6
Oropharynx	11.8*	3.3*	31.7*		14.1*	2.3*
Hypopharynx	3.6+	6.2*	16.9*		3.9*	0.4
Larynx	7.7*	4.6*	20.1*		6.9*	1.3
Oesophagus	2.2*	2.5*	6.2*		2.9*	1.0

*P < 0.0001 + P < 0.01 Courtesy: Jussawalla D J and Deshpande V A *Cancer* 28:244

Resolution of the World Health Assembly

AT ITS 39th meet held on 15 May 1986, the World Health Assembly passed the following resolution.

The 39th World Health Assembly,

"Deeply concerned by the current pandemic of smoking and other forms of tobacco use, which results in the loss of the lives of at least one million human beings every year and in illness and suffering for many more;

"Believing that the battle between health and tobacco must and can be won for the sake of human health;

"Encouraged by the existence of total bans, restrictions or limitations on tobacco advertising in several countries;

I. AFFIRMS: (1) that tobacco smoking and the use of tobacco in all its forms is incompatible with the attainment of health for all by the year 2000;

(2) that the presence of carcinogens and other toxic substances in tobacco smoke and other tobacco products is a known fact; and that the causal link between tobacco and a range of fatal and disabling diseases has been scientifically proven;

(3) that passive, enforced or involuntary smoking violates the right to health of non-smokers, who must be protected against this noxious form of environmental pollution;

II. CALLS for a global public health approach and action now to combat the tobacco pandemic;

III. DEPLORES all direct and indirect practices the aim of which is to promote the use of tobacco, as this product is addictive and dangerous even when used as promoted;

IV. URGES those Member States which have not yet done so to implement smoking control strategies; these, as a minimum, should contain the following:

(1) measures to ensure that non-smokers receive effective protection, to which they are entitled, from involuntary exposure to tobacco smoke, in enclosed public places, restaurants, transport, and places of work and entertainment;

(2) measures to promote abstention from the use of tobacco so as to protect children and young people from becoming addicted;

(3) measures to ensure that a good example is set in all health-related premises and by all health personnel;

(4) measures leading to the progressive elimination of those socio-economic, behavioural, and other incentives which maintain and promote the use of tobacco;

(5) prominent health warnings, which might include the statement that tobacco is addictive, on cigarette packets, and containers of all types of tobacco products;

(6) the establishment of programmes of education and public information on tobacco and health issues, including smoking cessation programmes, with active involvement of the health professions and the media;

(7) monitoring of trends in smoking and other forms of tobacco use, tobacco-related diseases, and effectiveness of national smoking control action;

(8) the promotion of viable economic alternatives to tobacco production, trade and taxation;

(9) the establishment of a national focal point to stimulate, support, and coordinate all the above activities;

V. APPEALS to other organizations of the United Nations system:

(1) to support WHO in all ways possible within their fields of competence;

(2) to show solidarity with WHO's efforts to stem the spread of tobacco-induced diseases by protecting the health of non-smokers on their premises, as this action would have a major exemplar role;

(3) to help Member States in identifying and implementing economic alternatives to tobacco cultivation, production and trade;

VI. REQUESTS the Director-General:

(1) to strengthen the present programme on smoking and health without waiting for its official introduction in the Eighth General Programme of Work, as a visible and resolute attitude on the part of WHO would provide Member States with encouragement and support, which are necessary prerequisites to abating the smoking pandemic before the year 2000;

(2) to mobilize support for the present programme on smoking and health in terms of funds and manpower which would ensure adequate programme continuity on a long-term basis;

(3) to coordinate activities in support of WHO's action on smoking and health with other organizations of the United Nations system at the highest executive level;

(4) to continue and strengthen collaboration with non-governmental organizations as appropriate;

(5) to ensure that WHO plays an effective global advocacy role in tobacco and health issues and that, in common with other health institutions, it plays an exemplar role in non-smoking practices;

(6) to provide support to national smoking control efforts;

(7) to report on progress to the Executive Board at its eighty-first session and to the forty-first World Health Assembly."

A Hundred Years Ago

From *The Times of India*

Friday, June 11, 1886

TOBACCO SMOKING

The following paper on the influence of tobacco-smoking on health was read by Dr. P. B. Bennie before the Australian Health Society, on April 15:—

The particular question now before us—the influence of tobacco-smoking on health-is a complex social problem which science has so far done little to solve. In perusing the literature of the subject I find that the writers may be divided into three classes. First, those who, on the one hand, treating the habit of smoking as a devil painted all black, hurl invectives against him with the ardour of fanaticism, and will not admit the presence of one bright spot in his dark character. Second, those who, on the other hand, ascribe to tobacco a divine origin, and speak of it as an angel in disguise, a panacea for all evils. Their eulogy, however, tempered by the pipe, forces from them the admission, "virtue in excess is vice". Third, those who hold that the rational treatment of the subject lies between these two extremes, and look upon the habit of smoking neither as devil born nor born of ministering angel, but as a human attribute, a natural disposition liable to abuse. This class is the most reasonable, for the inclination to use such substances as alcohol, tea, and tobacco, not for food, but for their peculiar action on the nervous system, has been, and is, so widely diffused throughout the world that we must, with Sir Benjamin Brodie, for this reason, look upon it as to a certain degree a natural instinct, and certainly the intelligent indulgence of our instincts cannot be regarded as prejudicial to health. I will now proceed to say a few words about the composition of tobacco smoke and its physiological effects on the human body...

This dilemma may be unique in medicine: A dangerous drug clearly should — but cannot — be banned.

An alternative approach is inherent in a new movement to protect passive smokers: banishing tobacco. This campaign includes either the prohibition of smoking in the workplace and in public buildings or the strict limitation of smoking to specified areas. The movement may be the single greatest success of the informational campaign against tobacco. Its leaders insist that non-smokers have every right not to be exposed to the carcinogens, carbon monoxide, and irritants in tobacco smoke. Such a campaign can make three important contributions.

First, by banishing tobacco use from places where innocent people will be exposed and placed at risk, thousands of lives may be saved. Second, forcing smokers to give up their habit while in the presence of non-smokers will provide them with an added impetus to quit. And third, by stigmatizing tobacco use as dangerous and antisocial, the passive smokers' rights movement can accomplish a goal of all antismoking informational campaigns to make smoking socially unattractive.

A particular difficulty in banishing tobacco is the role of government in promoting tobacco use. This schizophrenic state of affairs persists not just in the market-oriented West, but also in centralized economies. Governments most often own the tobacco industries in these areas. China, the Soviet Union and India, for example, grow their own tobacco — they are not victims of some cabal of multinational companies. The state-owned tobacco industry in China is being carefully nurtured and expanded rapidly even as another part of the government is telling the Chinese that smoking is bad for them.

These incompatible policies are also in place in the West. In the United States, the US Department of Agriculture administers a price-support system to protect tobacco producers. West European nations subsidize tobacco farmers with about $660 million in price supports each year. Ironically the systems protect small, inefficient farmers who earn higher prices than they would obtain without the subsidy. More efficient producers, who could underprice the small farmers, are not allowed to compete fully. The result is that tobacco costs the user more than it would without the system. As tobacco use varies negatively in response to price increase, smoking is being directly reduced by price supports.

There is an even more subtle effect, however. The tobacco industry, though it loses the right to compete with small-scale farmers for more of the profit of growing tobacco, gains the powerful political support of the small farmer. The added political clout helps counter anti-smoking forces. Moreover, it retains the appealing appearance of official tolerance and even endorsement of the use of tobacco, which in turn diminishes the effectiveness of the informational campaign in reducing the social acceptability of tobacco.

The overall situation of anti-smoking efforts, then, is at best a standoff in industrial countries and a rout in developing ones. Effective policies fall in four categories. The first, continuation of the informational campaign, is worthwhile as a foundation for the others. Now that this exists, at least in some countries, it is time to build on it with more stringent measures.

The second step is for those countries that have low smoking rates, no indigenous tobacco industry, and a reliance on imported tobacco products to ban tobacco altogether. To do so would completely eliminate the epidemic's threat to them, placing these nations in the forefront of the campaign, much as the industrial world spear-headed the campaign to eradicate smallpox. These governments have an economic incentive to act — the reduction of foreign-exchange losses for the purchase of a nonproductive product. Only a few people in these societies are now severely addicted, making national withdrawal politically easier. Many African nations fall into this category. Unfortunately, other impoverished nations, such as India, do not, because cigarette consumption is already high. The third approach is for those nations that must be politically pragmatic at least to act or protect the health of the innocent. Experience in the United States and in Poland shows that tobacco can be banished from public buildings, from the workplace, and from public eating establishments and meeting places. Banishing cigarette use in the presence of non-smokers should be considered a minimum level of protection.

All governments can provide national indoor clean air acts for public buildings, workplaces, and entertainment establishments. United Nations organizations would do well to establish no-smoking policies for their employees, especially those who work with children and the poor, for they are unavoidably going to be viewed as symbols of modernity and success, and therefore should not introduce such a clearly harmful product.

The fourth level is to use the power of economic tools to eliminate smoking as much as possible.

These measures will not be easy, nor will they solve the tobacco problem. They will not, for example, assure that children will be protected in the home against the smoke of their parents.

New measures will not assure that smokers themselves will be persuaded to quit. Nor will they guarantee that innocent young people do not become addicted before they realize their new habit eventually kills one out of four users. But without more responsible efforts on the part of the health professions and public interest organizations, even these efforts will be held in abeyance.

Dr Chandler is a senior researcher with Worldwatch Institute. This article has been condensed from the Worldwatch Paper 68, Banishing tobacco.

Worldwatch Institute, USA, is an independent, nonprofit research organisation created to analyze and to focus attention on global problems.

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Maths Olympiad: on your marks

THE MATHEMATICS Association of the Indian Institute of Technology (IIT) Bombay, conducts a Mathematical Olympiad in February every year. It's quite popular with science students in Bombay. This year there was a record 1200 odd entries split evenly between junior and senior college students. However, just over 600 students actually turned up at the venue according to the computer print out of the results. The reasons for the poor turnout was that India's final match against New Zealand in the Benson & Hedges tournament clashed with the Olympiad and unfortunately turned out to be a crucial one for India!

1. The ancient Greek philosopher Zeno gave his name to the famous mathematical paradox called Zeno's paradox. What topic in mathematics is Zeno's paradox concerned with?
(a) Topology (b) Set theory (c) Number theory (d) Infinite series (e) Probability

2. If 100! is factorized into its prime factors how many times will the factor 2 be repeated?
(a) 97 (b) 98 (c) 99 (d) 100 (e) None of these

3. The solution set of the equation

$$x = \cfrac{2}{2 + \cfrac{2}{2 + \cfrac{2}{2 + \ldots\ldots\ldots}}}$$

(a) $\{-1 \pm \sqrt{3}\}$ (b) $\{1\}$ (c) $\{-1 + \sqrt{3}\}$ (d) $\{2, \sqrt{2}\}$
(e) None of these

4. A certain mathematician always carried two boxes of matches, one in each of his trouser pockets. Whenever he needed a match, he put his hand into either pocket at random and took out that matchbox. (After using a match the matchbox was always returned to the same pocket. Also he used precisely one match every time.) Once on New Year's Eve, both matchboxes contained exactly five matches. On 5 Jan he put his hand into his right pocket and found that box to contain exactly one match. What was the probability that the other box contained exactly two matches?
(a) 35/256 (b) 40/256 (c) 45/256
(d) 50/256 (e) 55/256

5. Maximise

$$\frac{N\text{-}100_{C_{94}}}{N_{C_{100}}};\ N = 194, 195, 196 \ldots\ldots$$

(a) Maximum at N = 1600 (b) Maximum at N = 1660
(c) Maximum at N = 1666 (d) Maximum at N = 6666
(e) None of these

6. Brass is an alloy of copper and zinc; bronze is an alloy containing 80 per cent copper, 4 per cent zinc and 16 per cent tin. A fused mass of brass and bronze is found to contain 74 per cent copper, 16 per cent zinc and 10 per cent tin. Find the percentage of copper in the composition of brass.
(a) 36 per cent copper (b) 64 per cent copper (c) Data insufficient (d) Data contradictory

7. How many digits does the number $625 \times 2^{624} + 11$ have?
(a) 625 (b) 190 (c) 186 (d) 624 (e) None of these
(We are talking in the decimal system. $10g_{10}{}^2 = 0.30102$ correct upto 5 places after the decimal point.)

8. The equation $x^2 - 3xy + y^2 + 10x - 10y + 21 = 0$ represents:
(a) a pair of straight lines (b) a circle (c) a parabola (d) an ellipse (e) a hyperbola

9. Which of the following is true?
(a) $\pi < \frac{22}{7}$ (b) $\pi = \frac{22}{7}$ (c) $\pi > \frac{22}{7}$

10. What is the largest positive integer 'k' for which
$x^6 + 6x^5 + 21x^4 + 44x^3 + 62x^2 + 52x + 24$ is divisible for k for all positive integers $x > 7$?
(Hint: Put $y = x + 1$.)
(a) 3 (b) 4 (c) 5 (d) 6 (e) None of these.

11. Find the smallest positive integer which when divided by 11, 13, 17, 19 and 23, leaves a remainder of 10, 12, 16, 18, and 22 respectively.
(a) 46178 (b) 55912 (c) 1062346 (d) 62490 (3) None of these

12. Ramu went to a stationery shop to buy his requirement of notebooks at the beginning of the term. His mummy had given him Rs. 50. The shopkeeper showed him 80 page, 100 page and 200 page notebooks costing Rs 2, Rs 3 and Rs 5 respectively. Ramu bought ten notebooks and the shopkeeper gave him Rs 10 back. How many books of each kind did he buy?
(Note: The variables in the problem are constrained to take non-negative integral values only. Upper bounds on these variables are also available.)
(a) (1, 1, 7) (b) (2, 2, 6) (c) (3, 5, 2) (d) (0, 0, 10) (e) Data insufficient
(Here the first component of the triplet refers to 80 page notebooks, the second component to 100 page and the third to 200 page notebooks.)

13. How many of the following expressions are meaningful?
(1) $\log_7 \{\log_6 [\log_5 (\log_4 1000)]\}$
(2) $\log_7 \{\log_6 [\log_4 (\log_5 1000)]\}$
(3) $\log_7 \{\log_6 [\log_4 (\log_4 1000)]\}$
(4) $\log_7 \{\log_6 [\log_5 (\log_5 1000)]\}$
(a) None (b) One (c) Two (d) Three (e) All

14. Which of the following is a root of
$x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1 = 0$
(a) $\frac{\sqrt{3}+i}{2}$ (b) $\frac{1+i}{\sqrt{2}}$ (c) $\frac{-1+i}{\sqrt{2}}$ (d) $\frac{-1-i}{\sqrt{2}}$
(e) $\frac{1-i}{\sqrt{2}}$

15. What is the probability of getting the unlucky total 13 in five tosses of a fair die (six-faced).
(a) $77/6^5$ (b) $177/6^5$ (c) $277/6^5$ (d) $377/6^5$
(e) None of these

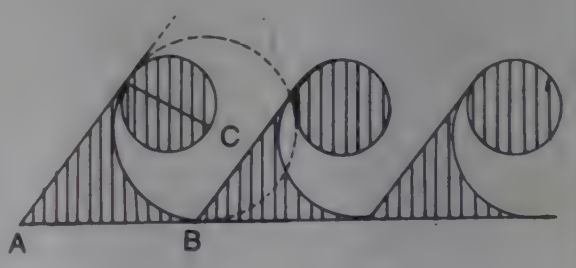
16. In the following addition problem, the digits have been replaced by letters. The same letter stands for the same digit wherever it reappears and different letters stand for different digits.

D	H	G	D	N	G	N	C
C	H	C	D	N	D	G	D
E	P	B	N	B	B	G	E

Find P
(a) P = 3 (b) P = 4 (c) P = 5 (d) P = 6 (e) None of these

17. My friend Ignatius always sends me a card on my birthday but I can't send him any, mainly because I don't know his birthday and he just won't tell me. One day I was pestering him to tell me his birthday. He said: "Well, if you were to multiply by 12 the day of the month I was born on, and if you were to multiply by 31 the number of the month I was born in, and add these products you would get 488". And then he wouldn't say another word. Can you tell which of the following is correct?
If x = month of his birth and y = day of his birth, then
(a) x and y cannot be determined uniquely. (b) The given equation has no solution satisfying all the constraints. (c) xy = 160 (d) xy = 180 (e) None of these

18. What is the area of the shaded portion in the figure?



Given: AB = $\sqrt{3}$, the radius of the smaller circle = 0.5.
(a) $\sqrt{3}/2 - \pi/12$ (b) $3\sqrt{3}/12 - \pi/4$ (c) $\sqrt{3} + \pi/6$ (d) $\sqrt{3}/2 + \pi/12$ (e) None of these

19. The total number of primes that can be represented both as the sum and the difference of two primes is
(a) infinitely many. (b) finitely many. (c) exactly one. (d) exactly two. (e) zero.

20. If k is a positive integer and 5400 + k is a perfect cube, what is the smallest value k can take?
(a) 1 (b) 2 (c) 3 (d) 5 (e) None of these

Maths Olympiad: on your marks

ANSWERS

1d. Zeno's paradox is clothed in a nice story about Achilles and a tortoise. Achilles can never overtake the tortoise because he has first to go half the distance, then half the distance left, ad infinitum.
answer: Infinite series.

2a. The two-times table gives 50 twos, the four-times table gives 25 more and so on. The sixty-four-times table gives one last two.
answer: $50 + 25 + 12 + 6 + 3 + 1 = 97$

3a. $x = \frac{2}{2+x}$
i.e. $x^2 + 2x - 2 = 0$
i.e. $x = -1 + \sqrt{3}$ or $x = -1 - \sqrt{3}$
Obviously $x = -1 \pm \sqrt{3}$ out of these choices.

4a. Let Success = puts hand into right pocket
and let Failure = puts hand into left pocket
Required probability
= Prob (3 failures precede the 5th success)
= Prob (3 failures in 7 trials)
= Prob (8th trial is a success)
$= {}^7C_3 \times \frac{1}{2^7} \times \frac{1}{2} = \frac{35}{256}$

5c. Let $f(N) = \frac{(N-100)}{94} / \frac{N}{100}$
$f(N)/f(N-1) = (N - 100/N - 194)(N - 100/N)$
Check that $(x-100)^2/x(x-194)$ is less than, equal to or greater than unity accordingly as x is greater than, equal to or less than 1666.66. So Maximum at N = 1666

6b. Ordinary algebra. The problem is taken from Hall and Knight's book: Higher algebra, Chapter 2.
answer: 64 per cent copper.

7e. $625 \times 2^{624} + 11 = 10^4 \times 2^{620} + 11$
$= 10^4 \times 10^{620 \log 2} + 11$
$= 10^4 + 10^{186.5+} + 11$
Answer: 191

8e. The equation of the second degree in x and y, $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ always represents one of the five alternatives provided. There are very simple rules which can be used to determine this (see Loney: The Elements of Coordinate Geometry) which everybody should know. In this case $h^2 > ab$ and this condition indicates a hyperbola.

9a. This question was set because though we are always using $^{22}/_{7}$ as an approximation to π, few stop to think about this question. If your calculator has a special button for π you can check that
$\pi = 3.14159$
$\frac{22}{7} = 3.14159$
i.e. to say $\pi < \frac{22}{7}$

10d. You must be good at algebra here. You must be adept at working with detached coefficients and using such aids as Pascal's triangle.
Substitute y−1 for x, expand, simplify, and put back y = x+1. Use the result: The largest integer k for which x(x+1)(x+2) is divisible by k for all positive integers x is k = 6.

11c. $(11 \times 13 \times 17 \times 19 \times 23) - 1 = 1062346$

12e. Note alternatives
(a) & (b)
$1 \times 2 + 1 \times 3 + 7 \times 5 = 40$
also
$2 \times 2 + 2 \times 3 + 6 \times 5 = 40$
Obviously the data is insufficient for a solution.

13c. We need, as you can check,
$1000 > 4^5 = 1024$; $1000 > 5^4 = 625$
$1000 > 4^4 = 256$; $1000 > 5^5 = 3125$
Only two of these are true

14a. $1 + x + x^2 + \ldots\ldots\ldots + x^{11}$
$= \frac{1(1 - x^{12})}{1 - x}$
using the formula for the sum of the first n terms of a geometric series
We can see that $(1 - x)(1 + x + x^2 + \ldots\ldots + x^{11}) = 1 - x^{12}$
and that if x = 1 but $1 - x^{12} = 0$
then $1 + x + x^2 + \ldots\ldots\ldots + x^{11} = 0$
i.e. to say the roots of given equation are also twelth roots of unity, x = 1 is the only twelth root of unity which is out of the question. Now, it is (or should be) easily observable that
$\frac{\sqrt{3} + i}{2} = \text{Cos } 30 + i \text{ Sin } 30$
$\frac{1 + i}{2} = \text{Cos } 45 + i \text{ Sin } 45$
$-\frac{1 + i}{2} = \text{Cos } 135 + i \text{ Sin } 135$
$-\frac{1 - i}{2} = \text{Cos } 225 + i \text{ Sin } 225$
$\frac{1 - i}{2} = \text{Cos } 315 + i \text{ Sin } 315$
and only the first is a twelth root of unity. (This question seems to be of a higher standard than XII Std. level but is certainly of Engineering Entrance standard)

15e. Number of ways of totalling 13
= Coefficient of x^{13} in $(x^1 + x^2 + x^3 + \ldots\ldots + + x^6)^5$
Formally: $(x^1 + x^2 + x^3 + \ldots\ldots + x^6)^5$
$= (x(1 - x^6)/(1 - x))^5$
$= x^5(1 - (^5/_1)x^6 + (^5/_2)x^{12} - (^5/_3)x^{18} + \ldots\ldots\ldots)$
$(1 + (^5/_1)x^1 + (^6/_2)x^2 + (^7/_3)x^3 + \ldots\ldots\ldots)$
Term in $x^{13} = x^5\left((^{12}/_8) - (^5/_1)(^6/_2)\right)x^8 = 420\,x^{13}$
Required probability = $420/6^5$

16e. The only clue seems to be N + G = G which might mean that N = 0 if nothing was carried forward from Column 1. But from Column 1, C + D ≥ E and from Column 8, C + D ≤ E. Thus C + D = E & N + G = G. We get successively N = 0, B = 1, D = 5, G = 6, C = 4, E = 9, H = 3, P = 7
Check

5	3	6	5	0	6	0	4
4	3	4	5	0	5	6	5
9	7	1	0	1	1	6	9

17c. No one can be expected to solve this one right in the short time given, it is true. Moreover a rigorous solution cannot fairly be expected of Junior College students. This question was thrown just to give all the best brains, something to struggle with. Below is the method of solving the equation 31x + 12 y = c, when it is known that it has a solution satisfying all the constraints. (If a solution exists it is unique) 31x + 12y = c
7x and c leave the same remainder when divided by 12
49x and 7c leave, etc.
x and 7c leave, etc.
x is the remainder when 7c is divided by 12, unless 7c is actually divisible by 12 in which case $\acute{x} = 12$
Now $488 = 12 \times 40 + 8$,
$7 \times 488 = 12 \times (7 \times 40) + 56$
The remainder when 7×488 is divided by 12 is, thus, 8.
Further x = 8 y = 20.
i.e. Ignatius was born on August 20.

18b. The problem boils down to finding the area of the conical hat like parts.
Note: Area of large circles = π
Area of small circles = $\pi/4$
Area if $\triangle ACB = \sqrt{3}/2$
Now, tan m $\angle ACB = \sqrt{3}$
m $\angle ACB$ = 60 degrees
area of sector = $\pi/3$
Area of conical hat like parts
$= 2(\sqrt{3}/2) - \pi/3$
Total area of shaded portion
$= 3\{\pi/4 + (\sqrt{3}/2 - \pi/3)\}$
Answer: $\frac{3\sqrt{3}}{2} - \pi/4$

19c. The first few primes are 2, 3, 5, 7, 11 .....
Note 5 = 3 + 2 = 7 − 2. Now the sum of two odd primes is even also the difference of two odd primes is even. We have, therefore, p = q + 2 = r − 2 where p, q, r are prime or x, x+1, x+2, x+4 are even. One of x+1, x+2, x+3, must be divisible by 3
3 divides x+1 ⇒ 3 divides x+4 ⇒ x+4 = 3
3 divides x+2 ⇒ x+2 = 3
3 divides x+3 ⇒ 3 divides x ⇒ x = 33
therefore, 3 is the only prime that is expressible as the sum and difference of other primes

20d. Check that
$5400 = 2^3 \times 3^3 \times 5^2$
Isn't it obvious from this that the smallest value k can take is 5.

Shocking stuff

"OUCH!" THAT'S what you'd say if you touched a live wire but didn't end up dead. In these days of electrified existence, there's hardly a person who has escaped this experience. Shocking, isn't it? But then, what exactly happens when you come in contact with a live wire? What is it that hurts you?

Electric shocks occur when — unintentionally — our body becomes part of an electric circuit allowing some current to flow through the body. The damage which results is primarily dependent on the amount of current that passes through the body. This current is determined by a relation called "Ohm's law". According to this law, the current flowing through a circuit is obtained by dividing the "voltage" (or more technically the "electric potential") of the circuit by the resistance in the circuit. The electric potential is measured in "volts" and the resistance in "ohms". The current that flows when one ohm resistance is connected across one volt is called one ampere. For example, the filament of an ordinary electric bulb (of about 100 watts) has a resistance of nearly 500 ohms. When this is connected to the usual household mains carrying a voltage of 250 volts, it will draw a current of 250/500, that is 0.5 ampere.

Now suppose you happen to touch a live wire at the same potential of about 250 volts. The current that will flow through you clearly depends on the electrical resistance of your body. The resistance of human skin is mostly in the upper (the so called "horny layers") epidermis, and varies widely with skin condition. Dry skin has a resistance between 1,00,000 ohms to 5,00,000 ohms, while even moderately wet skin has a much lower resistance — of around 1,000 ohms. So if the skin is dry it will draw a current of 250 volts/1,00,000 ohms which is 0.002 ampere. When wet, the same skin draws a current of 250 volts/ 1000 ohm, or 0.25 ampere.

Roughly speaking, the effect of current through the human body is as follows: At less than 0.01 ampere it produces just a tingling sensation. When it increases to 0.02 ampere the "tingling" becomes painful; often muscular contractions keep you "glued" to the wire. From 0.03 ampere onwards, breathing is disturbed and above 0.08 ampere breathing is very difficult. Currents in the higher range of 0.1 to 0.2 ampere initiate an uncontrolled, spastic twitching of the heart known as "fibrillation". The resulting disruption of the blood flow can lead to a quick death. In fact it has been found that the currents in the range of 0.1 to 0.2 ampere are the ones that cause most fatalities. Strangely enough, currents larger than 0.2 ampere are not effective in causing fibrillation; instead, they just stop the heart. Immediate first aid can revive the person. In addition, currents above 0.2 ampere can cause severe burning, and, of course, the victim stops breathing.

It might appear from the above discussion that it's probably not all that dangerous to grab a 250 volt wire if your skin is dry. That, unfortunately, is not true. The trouble is that the flow of current through the skin lowers the skin resistance dramatically. Thus the current flow through the body might start at a low value of 0.002 ampere; but it will soon increase to lethal levels. Another factor which adds to the danger is that voltages higher than 200 volts or so usually puncture the skin. (It very much depends on the local conditions at the point of contact.) While our skin resistance is high, the internal resistance of the body is fairly low and is between 100 and 500 ohms. So a puncture in the skin can shoot up the current flow to dangerous values.

Most of the time the victim gets "glued" to the electrical contact because of muscular contractions caused by the current. To avoid this, electricians usually use the back side (that is the "nail side") of their fingers while handling potentially live wires. If the contact draws current, the muscular contraction "throws" the finger away from the wire. In any electrical accident, the primary aim of the rescuer should be to break the contact between the victim and the current.

You may wonder at this stage about the birds that are perched on high voltage lines for minutes together. How is it that the current flowing through their body doesn't kill them? Well, there's a crucial difference between a man touching a live wire and a bird on a line through which a current is flowing. In the first case, the electric circuit is completed through the ground. In the case of the bird, the current through its body is driven by the potential difference between its two feet. A simple calculation will show that this current is far too small. If our bird, in a moment of stupidity pecks at the nearby neutral wire (or at any other grounded object), it will immediately be electrocuted.

Another biological phenomenon that seems to defy the above discussion occurs in electric eels. These marine organisms can produce a current of nearly one ampere at 600 volts or so. How do the tissues in their bodies tolerate this?

To answer this question one should know the distinction between a "series connection" and a "parallel connection". Normally, the batteries in your torchlight or transistor radio are connected in "series" — that is the positive end of one is connected to the negative end of the next one and so on. In this arrangement, the total voltage obtained will be the sum of the individual voltages (thus three cells of 1.5 volts in series will give 4.5 volts) but the current does not increase. We can also connect the cells in "parallel" — all the positive ends together and all the negative ends together. Now the voltage will be the same as that of a single cell but the currents will add up.

In the body of the electric eel there are certain cells (whether biological cells or electrical cells it doesn't matter right now) called electroplaques which can produce an ion flow across their membranes. This flow is triggered by a nerve impulse from the brain. These electroplaques are arranged with about 1000 cells in series and 2000 such series wired up in parallel. In the salt water giant ray (*Torpedo nobiliana*) each electroplaque produces about 0.15 volt. The series arrangement of 1000 plaques lead to a thousand times higher voltage between the head and the tail of the fish. On the other hand, the 200 or so such series connections assure a high enough current to kill its prey. If all the cells were in series the fish would be rather long; besides, the current would destroy the tissues. The combined parallel series wiring keeps the current through each cell small without sacrificing the external current.

T PADMANABHAN

Dr Padmanabhan is with the Theoretical Astrophysics Group, TIFR, Bombay.

MINDWINDOWS

ACROSTIC

EACH SMALL rectangle in both diagrams is identified by two letters: the first indicates the row and the second the column in which the rectangle stands. There is a one-to-one correspondence between rectangles of both diagrams; this is defined by entering at the top of each rectangle the letters identifying the corresponding rectangle in the other diagram.

The rectangles in the first diagram are to be filled with the help of the clues given, and the letters of the answers are to be transferred to the corresponding locations in the second diagram, which is to be read in the normal manner, that is, row by row; bars mark the ends of individual words except where words end at the right of the diagram. However, a word need not necessarily end at the right of the diagram and may spill over into the next row.

After the few letters have been entered into the second diagram, it may be possible to guess additional letters required to complete a particular word; these, transferred back to the first diagram, will help one in solving more clues. Working back and forth in this manner, the solver is expected to fill in all the rectangles in both diagrams.

In the completed puzzle, the second diagram will present an opposite quotation whose source (that is the name of the author and the work from which the quotation is taken) is spelt out by column "a" in the first diagram read downwards.

EASWAR AIYAR

Mr Aiyar is a chemical engineer whose hobby is compiling acrostics and crosswords.

	CLUES	a	b	c	d	e	f	g
a	C G S unit of work	cr	de	fp				
b	A form of water	cj	ej	fh				
c	Hypothetical core of the earth	ca	eq	fk	ad			
d	Of tetravalent tin	ce	fr	am	ae	cp	ei	dk
e	Pointed parts of leaf-margins	cg	dj	bj	aj	fq		
f	Containing oxygen bonded to adjacent carbon atoms	bg	ar	fj	db	ch		
g	Having all teeth similar in shape and size	ac	cn	dl	br	fn	ep	ao
h	Point at which a curve crosses itself	dh	bc	eb	ag			
i	Of the ear	ci	fg	df	af			
j	Common fertilizer	cl	dm	al	ek			
k	Cutting-parts of lathes, shapers, etc.	an	bn	dr	el	cq		
l	Female gamete	ed	cb	fo	aq			
m	Field-effect transistor (abbrv)	cj	da	ec				
n	Unit of electrical conductance	fc	bl	fa				
o	Bar of soft iron between the poles of an electromagnet	fe	eg	bj	dg			
p	Electromagnetic radiation in the visible range	em	ca	eh	bi	fl		
q	SI unit of current (abbrv)	bm	bd	dq				
r	An acid magnesium silicate	ba	be	cf	ab			
s	Eat away with acid	dd	bb	bk	fm			
t	Gold-bearing lode or vein	cd	ap	do	er			
u	Trivalent element resembling the rare earths	en	bh	bo	cm	ah	co	fi
v	An asteroid that **approaches** the earth very closely	cc	fb	ck	ai			
w	Powdery stuff ejected by a volcano	ec	fj	ak				
x	A construction material in civil engineering (abbrv)	dn	bq	di				
y	Invasion by pathogenic bacteria	aa	co	dc	fd	bp	dp	

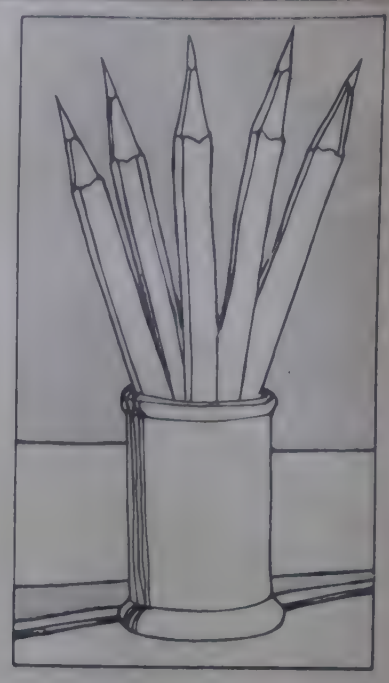
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
a	ya	rd	ga	cd	dd	id	hd	ue	vd	ed	wc	jc	dc	ka	gg	th	ld	fb
b	ra	sb	hb	qb	rb	oc	fa	ub	pd	ec	sc	nb	qa	kb	uc	ye	xb	gd
c	pb	lb	va	ta	da	ba	ea	fe	ia	ma	vc	ja	ud	gb	yb	de	ke	aa
d	mb	fd	yc	sa	ab	tc	od	ha	xc	eb	dg	gc	jb	xa	tc	yf	qc	kc
e	ca	hc	mc	la	wa	rc	ob	pc	df	bb	jd	kd	pa	ua	uf	gf	cb	td
f	nc	vb	na	yd	oa	wb	ib	bc	ug	fc	cc	pe	sd	ge	lc	ac	ee	db

SOLUTION TO APRIL'86 ACROSTIC

The truth is, the science of Nature has been already too long made only a work of the brain and the fancy: It is now high time that it should return to the plainness and soundness of observations on material and obvious things.

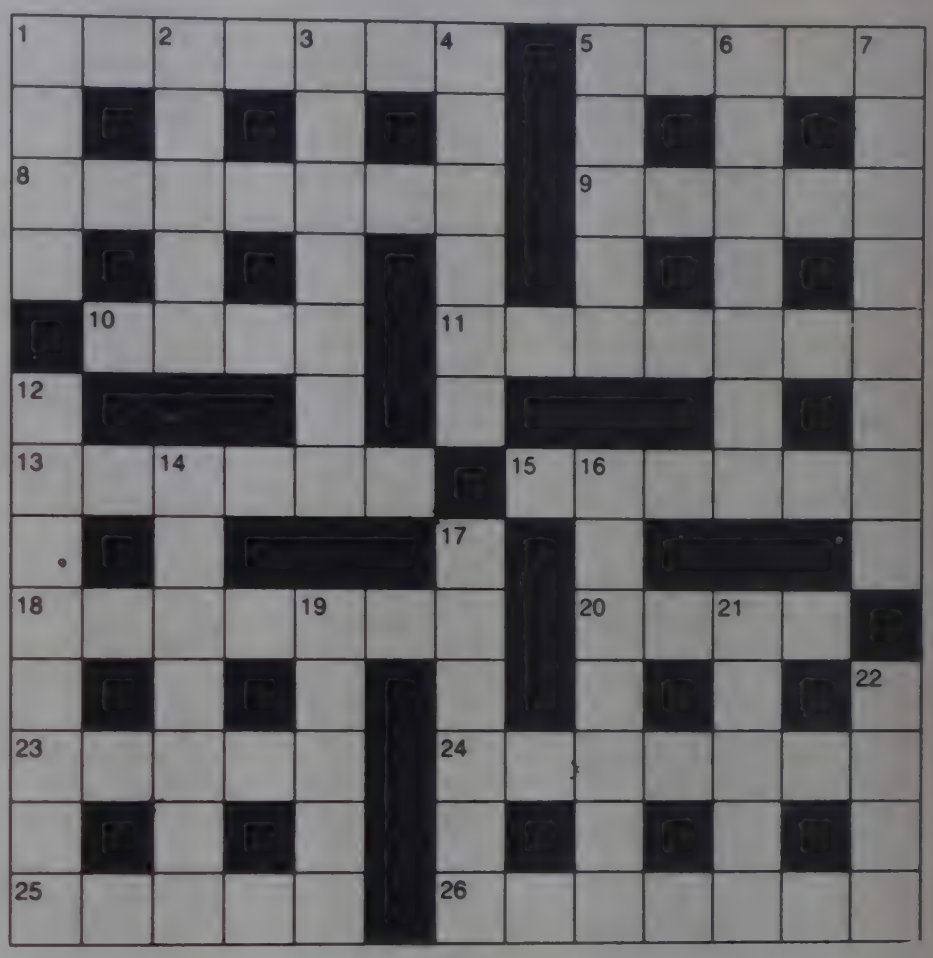
ROBERT HOOKE.
Micrographia

CROSSWORD



ACROSS

1. To inhibit first make a way (7)
5. Tough material obtained after 13Ac treatment (5)
8. Almost half and very badly a superficial pattern (7)
9. Trouble at the lowest point for a transistor terminal (5)
10. Instructional sequence for the return of dear ones
11. Psychological complex does one up in a bad way. (7)
13. Make suitable by returning the encounter with an agent (6)
15. This is the start of the compaign stick! (6)
18. Exhibit neurosis when its wrong to take any exit (7)
20. Faithful reproduction using carbon? (4)
23. Without you the broken pod is one of two units (5)
24. Home having a cover around a boring tool (7)
25. Pay back for the stop-watch (5)
26. Indian antelope wants badly to be ill in the first part of the night (7)



DOWN

1. Mathematical quantity on a fundamental particle (4)
2. Last of 1Ac happens to be a point in space-time (5)
3. Directions around fasteners cause a heavenly shadow (7)
4. Antiseptic deodorant is a sacred transition metal compound (6)
5. Was partial to the kind of figure a square is (5)
6. Illustration in case the exam pleases you (7)
7. Having lied, sent around for growing flax (8)
12. Kind of angle directly summing up the angles in a triangle (8)
14. Largely the greatest brilliance of a star (7)
16. Sound measure can be eaten together with carbon (7)
17. Boa sounds as if 1 Dn eats up thorium (6)
19. Mathematician giving you a spin around (5)
21. High frequency screw gauge (5)
22. Case for carrying needles in which one may take tuitions (4)

M J PATNI

Dr. Patni is with the Materials Science Centre, IIT, Powai Bombay.

Solution to April '86 crossword

ACROSS

1. THREE-WAY 5. SOLE 8. BLUE 9. INSULATE 10. LEECHES 12. DIGIT 13. REMOVE 15. PULSED 17. BOXER 18. SCHOLAR 22. SCUTELLA 23. SNUB 24. CUED 25. GAMMA-RAY

DOWN

1. TUBULAR 2. ROUGE 3. WRITE 4. YETI 6. ORANGES 7. EJECT 11. HOVER 12. DOUGH 14. MIXTURE 16. DURABLY 17. BASIC 19. CHASM 20. LINER 21. PLUG

IC audio amplifier

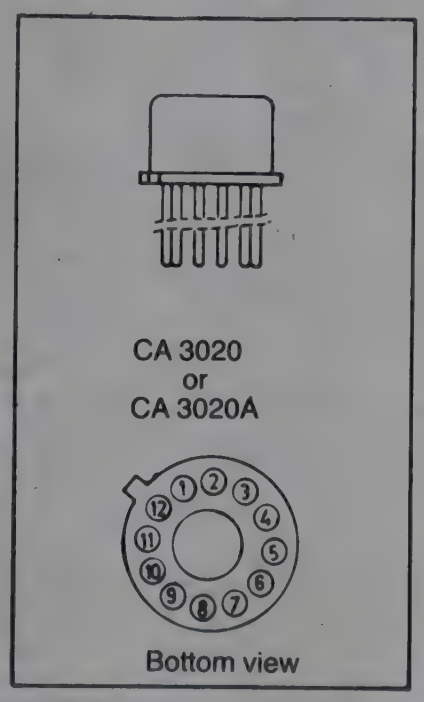
INTRODUCING a new indigenously manufactured integrated circuit wide band power amplifier CA 3020. This IC can be used as an audio amplifier for a record player, a tape recorder or a radio tuner. Its output is about 500 mW, quite sufficient for a portable amplifier.

The schematic internal circuit diagram of the IC shows equivalent circuit details of the IC. For simplicity of understanding the diagram shows distribution of internal circuit in five functional blocks.

The first block consists of Transistor Q1 and is used as a buffer, that is, an emitter follower. The external potentiometer which connects this stage with the second acts as a volume control. The second stage consists of three voltage regulator diodes and resistors. This stage provides voltage regulation necessary for the operation of the third stage. The third stage consists of transistors Q2 and Q3 and a few resistors in differential amplifier configuration. This stage provides balanced split phase signals, necessary for the push-pull operation of the remaining stages. The fourth stage is the driver stage and consists of transistors Q4 and Q5 in emitter follower configuration. This stage drives the last, that is, the output stage, which consists of transistors Q6 and Q7 as push-pull amplifier. This stage drives the loudspeaker through an external impedance matching push-pull output transformer. The 1 ohm resistor in the common emitter path of both transistors Q6 and Q7 provides current limiting action which protects the transistors under overload conditions. The internal negative feedback between the third and fourth stage, through resistors R5 and R7, is for stable operation and flat frequency response of the IC amplifier.

The 0.1 mfd capacitor across the primary of the output transformer is for frequency compensation. You may select suitable value anywhere between 0.022 mfd to 0.47 mfd to suit your listening taste.

The chart given below shows approximate current distribution using 9V dc supply for no signal and maximum output conditions. The detailed technical specifications of this audio amplifier are given below the circuit diagram.



	No Signal mA	Max Signal mA
I1	22	150
I2	12	135
I3	10	15

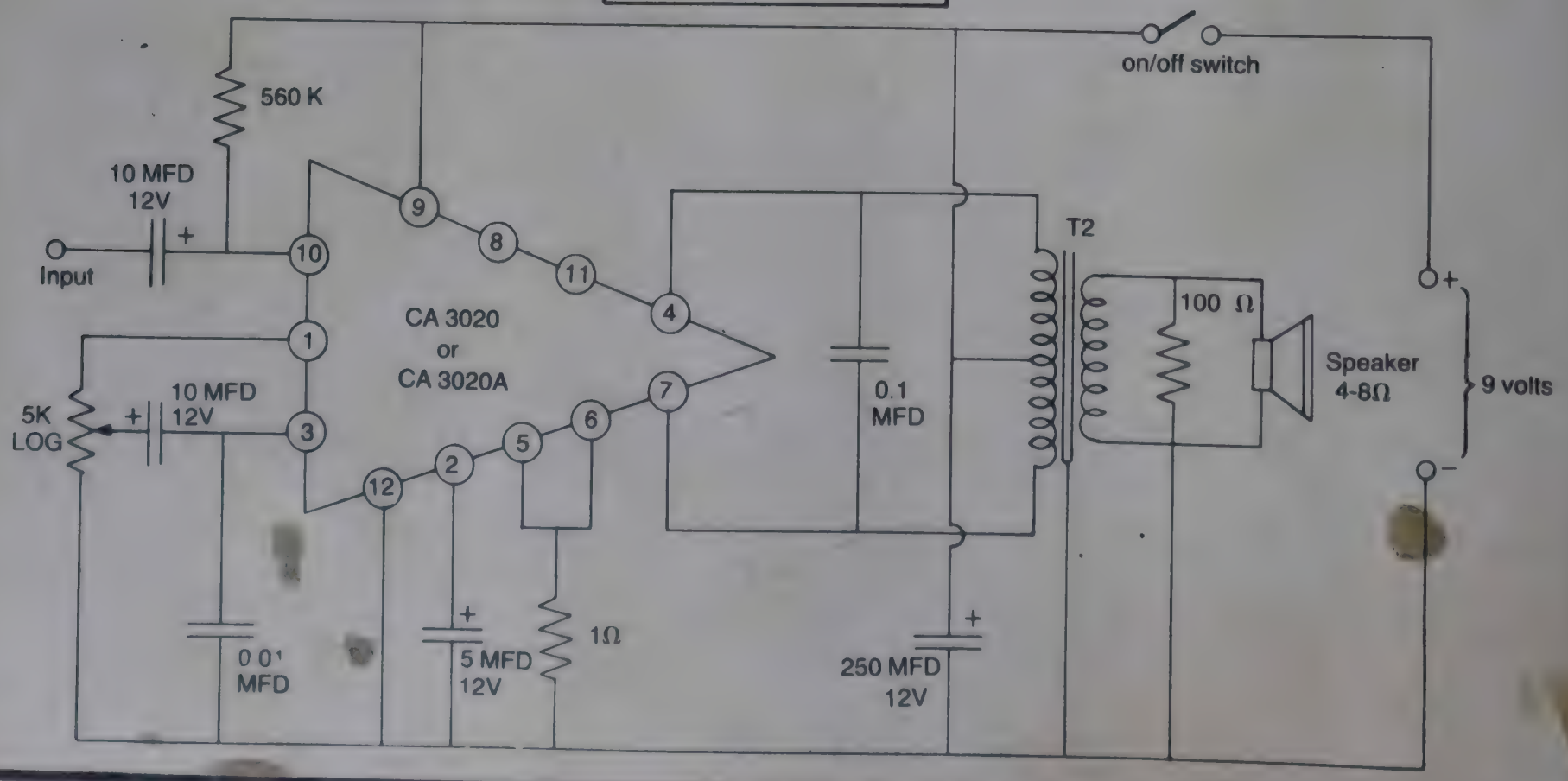
where I1 is total supply current, I2 is current through transformer T2 and I3 is current through IC pin no. 9.

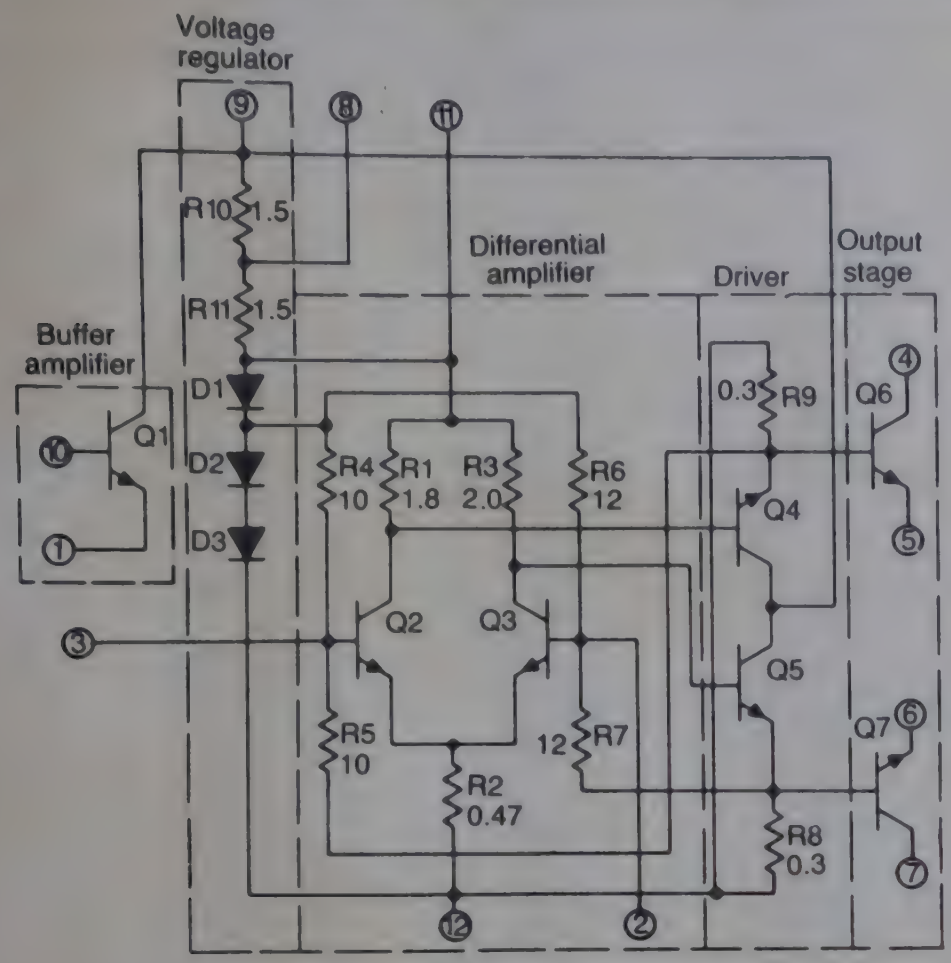
The construction of the audio amplifier using IC CA3020 requires very few external components. The circuit is both miniature and simple. You may place the entire circuit, including the 9V batteries/power supply, inside the loudspeaker enclosure. Make sure you use a shielded cable at the input. After construction you may connect the amplifier directly to a record player having a ceramic/piezo pick up cartridge. You can even connect the amplifier directly to the line output of a cassette tape recorder or a radio tuner.

You can use any loudspeaker which can handle 500 mW or more. The larger diameter 150 mm or 200 mm loudspeaker will provide better results. Make sure that the output transformer secondary impedance matches with the impedance of the loudspeaker.

SPECIFICATIONS

Supply voltage =9VDC
Power output = 500mW
Max input = 50mV
Input impedance = 50KΩ
Frequency response (±3d B) = 50 → 15 KHz





Schematic diagram — CA 3020/CA 3020A Resistance values in K ohms.

You will need :

Integrated Circuit : CA 3020 or CA 3020A — 1 No.
Capacitors : Electrolytic:
250 mfd 12 V — 1 No; 10 mfd 12 V — 2 Nos; 5 mfd 12 V — 1 No; Polyester or Ceramic:
0.1 mfd — 1 No; 0.01 mfd — 1 No.
Resistors : All half watt type
560 K — 1 No; 100 ohms — 1 No; 1 ohms — 1 No.
Potentiometer : 5 K log with switch — 1 No.
Transformer : Output transformer push pull type pri : 100 to 180 ohms sec : to match with the loudspeaker — 1 No.
Loudspeaker : 150 mm dia 4 to 8 ohms 3 W or more — 1 No.
The approximate cost of the above electronic components in Bombay is Rs 75
Power Supply : 9 Volt battery pack or battery eliminator — 1 No.
Misc : Screws, wires, solder, shielded wires, knob, suitable enclosure etc.

ANIL V BORKAR

Mr Borkar, a radio and electronics engineer, is technical director of an industrial electronics concern in Bombay.

OH, THESE SCIENTISTS!

A British firm once asked P L Kapitza, a Russian physicist who worked in Britain for some time, to repair a new electric motor, which for some unknown reason would not work. Kapitza examined the motor thoroughly, switched it on and off several times, and then asked for a hammer. Giving it a moment's thought, he struck the motor with the hammer and it began to work. For this consultation, the firm had paid Kapitza £1,000 in advance. An official of the firm, seeing that it took only a few minutes to put the motor right asked Kapitza to produce a written account of the money received. Kapitza wrote that he believed the hammer blow was worth one pound, while the remaining £999 had been paid to him because he knew exactly where to strike.

* * *

When Philipp Frank was visiting Berlin during the war (1914-1918), Einstein invited him to his uncle's house for dinner. There Frank met Einstein's cousin Elsa for the first time. She said to Frank in a mixed tone, "I know very well what a talented physicist our Albertie is. In these times we have to buy food in all kinds of cans which no one knows how to open. Often they are of unfamiliar foreign make, rusted, bent and without the key necessary to open them. But there hasn't been a single one yet that our Albertie hasn't been able to open."

* * *

When Niels Bohr was young he was a good soccer player. But sometimes, instead of kicking the ball towards the opposing goal, he would pick it up in the middle of the game in order to see precisely what that sphere of leather really contained.

* * *

In 1932, the government had placed at Bohr's disposal the Castle of Carlsberg as a gesture of appreciation for the most learned man in Denmark. When Bohr left the castle on his bicycle for the institute, he hardly ever used to take any notice of the traffic lights. If he travelled by trolley he was often so deep in thought that he not only passed his stop and went on to the terminal, but occasionally forgot again to get down at the same stop on the return journey.

* * *

When George Gamow, L D Landau and B G Casimir were at Niels Bohr's Institute in Copenhagen, they often went to the movies together. They sometimes succeeded in taking Bohr along with them to see the film they had selected. Bohr used to introduce some of his ideas on observations and measurements into his criticism of the film. Once, after a thoroughly stupid Tom Mix film, he commented: "I did not like that picture, it was too improbable. That the scoundrel runs off with the beautiful girl is logical, it always happens. That the bridge collapses under their carriage is unlikely but I am willing to accept it. That the heroine remains suspended in mid-air over a precipice is even more unlikely, but again I accept it. I am even willing to accept that at that very moment Tom Mix is coming by on his horse. But that at that very moment there should be a fellow with a motion picture camera to film the whole business — that is more than I am willing to believe."

* * *

In 1881 Louis Pasteur attended the International Medical Congress in London. When he entered St James Hall there was an outburst of applause and hurrahs. Pasteur said to his companions, "It's probably the Prince of Wales arriving, I should have come earlier". "No, it's you whom they are cheering", said the president of the Congress.

PRABHAT DATTA JHA

The Power of the Atom

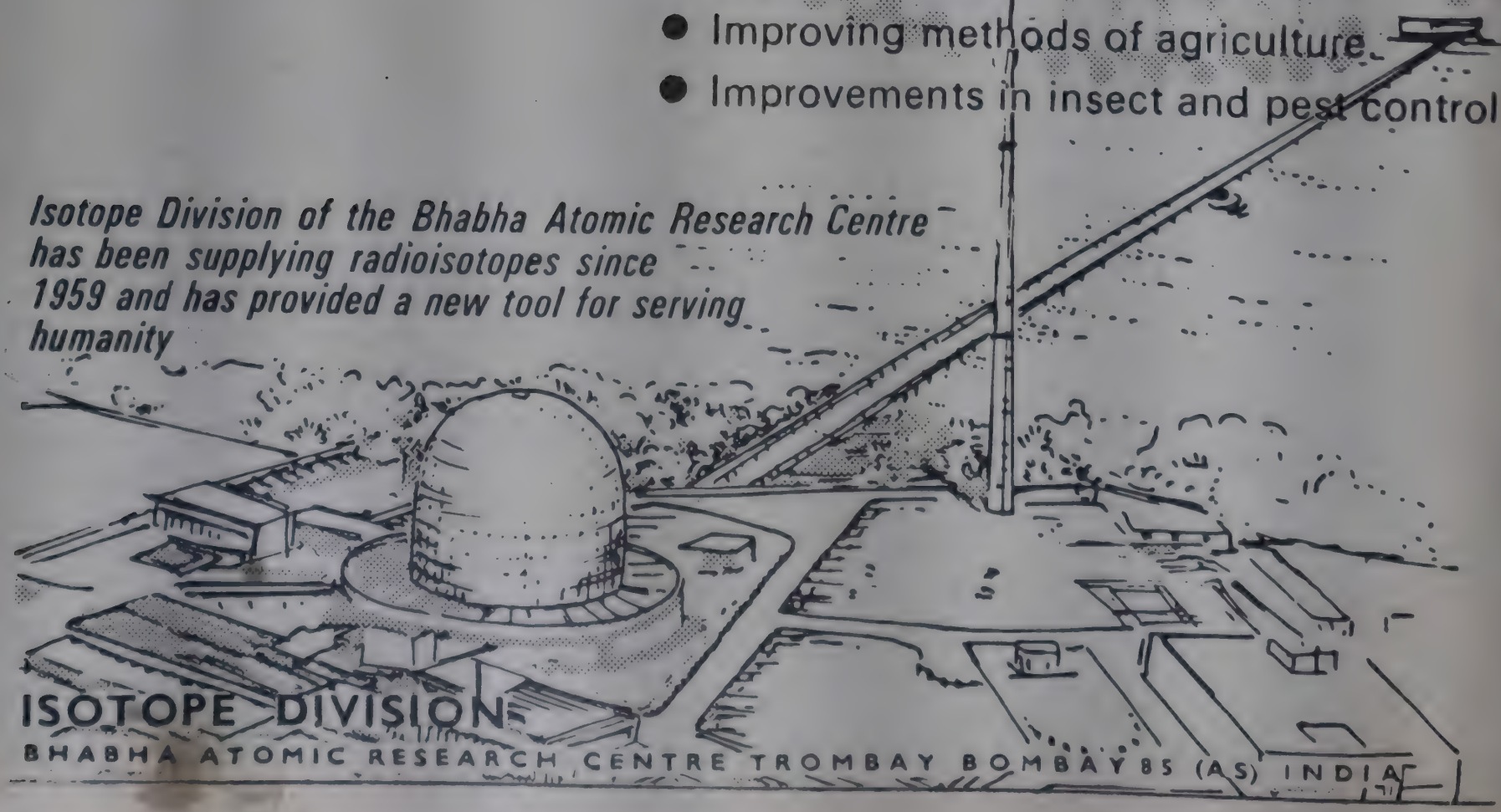
Do you know that in the single dot of a full-stop there are more atoms than there are people in the world? And that the fission of one gram of Uranium 235 for one day generates one million watts of energy?

The source of this tremendous, bountiful energy is the Atom. The energy released during the splitting of an atom is called nuclear energy. Nuclear energy harnessed in the appropriate way can spell spectacular advances for mankind.

A by-product of nuclear energy is the radio-active isotope. In India radioisotopes are being utilised for:

- Understanding, prevention and treatment of diseases.
- Sterilisation of medical products
- Quality testing and process control in Industry.
- Study of erosion, silt movement and ground water.
- Improving methods of agriculture.
- Improvements in insect and pest control

Isotope Division of the Bhabha Atomic Research Centre has been supplying radioisotopes since 1959 and has provided a new tool for serving humanity



A freshwater aquarium for your home

IFE UNDERWATER is as fascinating as life above ground. In fact it may be ven more fascinating. We have an inhe-nt love for water and the underwater orld is so very different from ours, right om the medium of respiration.

Unfortunately, this very fact keeps us way from observing underwater life inti-ately. Unless we do skin diving. But at's a clumsy alternative, particularly if e wish to look at life in a quiet pond. So hat should we do? I suggest you set up an quarium of your own, and see the differ-nce it makes to your life.

The minimum size one could go for is 60 30 × 30 cm and the maximum has a ngth of 2.4m or more; but a beginner hould not try his hand on anything longer han 91 cm. In a reasonably spacious rawing room one can conveniently ccommodate a 1.2m aquarium. In a smal-r room one may have to settle for a 60 m aquarium with all its disadvantages. ut do not make it smaller than that: it will e very uncomfortable for even small fish.

The aquarium should have a removable lass top. There should at least be a half-nch space between the top glass and pper edges. This is to allow free air flow ver the water surface.

When you buy an aquarium from your ealer, either ready-made or made to rder, make sure that the height (depth) is ot more than the width. A large surface rea is essential to facilitate the easy mix-ng of atmospheric oxygen in the water nd the quick removal of carbon dioxide reathed out by the fish.

This reminds me of the occasion I went o the house of a well-educated gentleman n Bombay who kept guppies in two glass ars, each about a foot high and four nches in diameter, with money plants rowing out of them. When I asked whether the fish weren't unhappy, pat ame the reply; "When they are alive they re happy, and when they are dead they annot be unhappy!"

The weight of water in an aquarium is urprisingly deceptive. Would you believe hat there are about 54 kg of water in a 0 × 30 × 30 cm aquarium! This weight alls for two things: The glass walls should e thicker than those available when you urchase the aquarium ready made. For a 0 cm acquarium, the thickness of the lass should be four mm. Sizes up to 1.2 m n length can have six mm glass.

Before placing the aquarium on its site, we should consider whether the bottom support (say a stand or a wooden shelf) on which the aquarium is to stand is strong enough to withstand the weight 24 hours a day, and whether the floor — usually it's someone else's roof in cities — is strong enough to support this constant extra weight. The floor is strongest near the wall. A weakly supported balcony would be a dangerous choice.

The height as well as the location of the aquarium are critical too. It should be kept at more or less eye level; to make it convenient to watch even when seated. Placing an aquarium too high or too low will affect viewing pleasure, the very purpose of owning it.

As for the location, the options are limited. Keep the aquarium in a place where natural light flows in. Direct sunlight should, of course, be avoided and the aquarium water should not heat up in summer. Diffused light is what is needed, but even too much diffused light will induce excessive growth of green algae on the inner surface of the glass walls. At the same time, if you place the aquarium in subdued light you may attract undesirable brown algae which keep covering the glass like dirt, in spite of repeated cleaning. We should strike a balance. This will come only with experience. Where there is excessive light you can easily regulate it without shifting the position of the aquarium. But if the lighting is insufficient, you have to shift it.

I had much trouble from brown algae in a 60 cm aequarium until I raised it barely 7.6 cms above the original position, allowing just the extra amount of diffused light needed to strike the balance.

It would be advisable not to depend much upon artificial lighting for plant growth and release of oxygen. One or more tube lights — depending upon the size of the aquarium — will make for excellent viewing and at the same time make a limited contribution towards plant growth.

If you cannot give natural light at all, you can go in for ordinary light bulbs, the wattage requirements to be decided according to the size of the aquarium. A 90 cm aquarium would require two 60-watt lamps lit right above it for about six hours a day. You should experiment and find out your own optimum, depending upon the type and amount of plants you wish to grow in the aquarium. Certain plants do not require much light.

Talking about plants, there are several dozens of varieties suitable for tropical fresh water aquariums. But there can only be a few that are suitable for *your* aquarium, because that depends on its size, location the availability of plants, and your taste. Keep three things in mind. Select slow-growing plants, avoid giant plants, like the Amazon sword plant in small aquariums, and do not overcrowd the aquarium with plants so that they affect the easy movement of fish, your viewing convenience, and the easy penetration of light. Plants contribute 50 per cent or more to viewing pleasure, apart from making the aquarium a liveable habitat for the fish.

Some of the groups of aquarium plants well known in India are

Robert Grubh

Aqua rose (*Synnema triflorum*) Aponogeton, aqua 'Fern' (*Ceratopteris sp.*) Valisnaria, Sagittaria, Cabomba, and Elodea.

Of the hundreds of varieties of fish sold around the world for tropical fresh water aquarium, your local dealer may be able to sell you at least 30 to 40 varieties during different seasons of a single year. So you can choose. But one should be careful. Apart from the general rule of smaller fish for smaller aquarium one should also avoid fish with "bad" habits, such as stirring up sand, damaging plants and being a constant menace to peace-loving fish. More about the fish later.

After the aquarium is in its place (it can't be moved after filling it with water), you will need: Plenty of sand, preferably river sand; large and small stones with somewhat flat bottoms and some gravel, all preferably picked up from slow stream beds or ponds; aquatic plants; fishes; a hand net to transfer fish; enough chlorine-free, clean fresh water of pH value around seven; and an old newspaper.

Clean the sand repeatedly in plenty of water until it is absolutely clean. Then fill the aquarium with it to a depth of about 5 cms. Arrange a few of the stones over the sand like natural rocks in a pond, according to your taste. Do not put anything artificial. Do not place sea shells either. If we expect full satisfaction from an aquarium it should look as close to nature as possible. Sea shells do not belong to a fresh water aquarium.

After arranging the stones over the sand, fill two-thirds of the aquarium with water. One way to pour water without stirring up the sand is to place a newspaper over the bottom and pour water over the newspaper. Remove the newspaper carefully and start planting. Plants should be firmly placed by guiding the basal ends deep into the sand. No manure is to be added. The fish will provide enough plant nutrients through their excreta.

While arranging the plants make sure to provide some dense clumps where the fish can take shelter or just keep away from light when they want to. The intensity of available natural light will not be uniform throughout the aquarium; and some plants require more light than others.

While arranging the aquarium bed do provide some hiding places for hole-dwellers such as *Labeo bicolor*. A cave that will attract fish can be made by burying a piece of plastic pipe between the rocks or below the sand, keeping only the ends open. You may also provide different types of bottoms in the same aquarium such as sandy, gravel and rocky. The beauty is when spirogyra, the green hairy alga, starts growing on the rocks on its own! Try and make as many microhabitats as possible within the available space, using plants, rocks sand and the like. This will tremendously increase the ecological dimensions of the aquarium and will provide a source of enjoyment to you as well as the fish you keep.

Once the plants are in their place, and the bottom done up, you can fill water to the top. Then place the glass top and allow the water and the plants to settle down for a day or two. If you use water directly from the tap this settling time will also help remove all dissolved chlorine, if any. But do not keep the aquarium without fish for many days: mosquitoes may start breeding then!

Now to make your aquarium come alive. While transferring fish from the container to the aquarium make sure that there is not much difference between the temperatures of the water in the container and the water in the aquarium. Any sharp difference can mortally affect the creatures.

How many fish can you accommodate in an aquarium? Apart from what the fishes may prefer, it has been estimated by some that at least 19 cm^2 of air surface per fish of 5 cm average length, is essential for simple survival. To give you an idea, in a 60 cr aquarium you can comfortably accommodate six guppies, two black (or lyre-tailed) mollies, two platys, half a dozen neon tetras and two glass tetras. Air breathers require less area.

Loaches are scavengers, so people like keeping them. But they have the habit of constantly flushing out settled dirt and fish excreta from the sand, resulting in cloudy

water and dirty plant leaves. Goldfish have the habit of picking up mouthfuls of dirt from the bottom and spitting it out, thereby gradually building up a muddy cloud. In a pond we see many fish, of different sizes, habits and temperaments. They all, as species, co-exist except under special circumstances. Each species has its own ecological *niche* or area of operation which prevents competition for survival. The availability of a large space and numerous hiding places also enable weaker fish to keep away from the aggressive ones.

But an aquarium is not a pond. Therefore we should introduce only those fish and age groups that can live peacefully in the limited space available. The smaller the aquarium, the greater the care needed in choosing the fish. The gorgeous Siamese fighter is a loner and will survive even in a jam jar, but when kept with other fishes of similar size it repeatedly chases and attacks them without provocation. Lovely veil-tailed guppies frequently end up with torn tails. Labeos like *L. bicolor* are beauties but do not belong in a small aquarium. The selection of fish suggested earlier will suit a 60 cm aquarium.

For a 90 cm aquarium you can add a pair or more of each of these species and also introduce a few new varieties, such as a pair each of half-grown angel fish, sward-tails and tiger barbs. A 1.2 m aquarium can, in addition to these fishes, take a pair each of labeos and gouramis. You should experiment with the fishes yourself, under the general guidelines discussed above.

Fish breeding will be difficult in a community tank. Egg-layers have very little chance – young hatchlings are excellent food for fish! The Siamese fighter will of course defend the very young if he is the father, but we do not intend keeping it in a community tank anyway. The guppies, mollies and sword-tails on the other hand are live-bearers and the young are quite large when they come out of the mother. A well-planted large aquarium will certainly provide hiding places for at least some of these young to escape predation and grow up.

Most fish love non-vegetarian food. Even those which feed upon green algae require animal protein regularly. Live or fresh items are preferable to preserved food. Tubifex (commonly known as just "worms") and daphnia are excellent food. If you have a refrigerator, keep uncooked meat and fish to be fed after shredding into tiny bits. Fish find fish eggs a delicacy. You can also get other types of dry and live food from the aquarist.

As for feeding the fish, the golden rule is never put more food than can be eaten in five minutes. Feeding just once a day at a particular time during the day is sufficient. If you put more food than the fish can pick up within a few minutes the excess food will rot and lethally contaminate the aquarium. Resist the temptation to be overkind.

How long can the fish go hungry? If they are healthy and regularly fed, they can easily withstand hunger up to two weeks or more. If you have to go out of town for a week or two you would be better off just starving the fish than asking a novice to feed them in your asbsence.

If you keep just the optimum number of fish you don't need aerators for community aquariums. They remind one of artificial respirators. Aquarists require them because they keep for sale much more fish in an aquarium than can comfortably live. Aerators also have the disadvantage of not allowing dust to settle fast.

A well balanced tropical fresh-water aquarium does not require water to be changed for a very long time. The water in such an aquarium is crystal clear, much clearer than tap water or water from the river, and would normally require only weekly topping up in order to compensate for evaporation. However, if the occasion arises to replace part or whole of the water, use only chlorine free clean water. A water filter is unnecessary in a balanced aquarium. However, if you are keen to keep goldfish – their beauty and grace are matchless, of course – you do need a good filter. In any case, do not keep goldfish in a small aquarium. Dirt stirred up by fish will also soil the plant leaves. Clean plants add immensely to the beauty of the aquarium.

The inner surfaces of the aquarium walls gather dirt gradually and they require weekly cleaning with a piece of old cloth. As for the excreta of fish, these get assimilated into the bottom sand and are broken down by micro organisms to form excellent manure for the aquarium plants. The tiny live-bearing nocturnal conical snails that often come with aquarium plants are excellent scavengers. Do not encourage other snails.

Water can be either acidic (pH value below 7), normal (pH 7) or alkaline (pH above 7). Slightly acidic water (a trifle below 7) brings out the best of colours in fish such as tetras whereas others, like the black molly, thrive in alkaline waters. However, if the water is near normal you can keep a wide variety of fish. Stored rain water will make a good alternative where good water is hard to get.

When you purchase fish from the dealer accept only healthy and active fish. Ideally, one should quarantine any new fish before introducing it or them into a healthy aquarium. This is often unpracticable at home. But do keep the fish in some water taken from your own aquarium before transferring into the aquarium itself. This is to atleast prevent any contaminated water from getting into your aquarium. The worms and daphnia purchased from the shop should be washed in clean water before feeding the fish. In case some of your fish show signs of illness, even remotely, take them out so that they cannot infect healthy fish. Certain chemicals, when added to the aquarium water act as effective purifiers of water and even a cure for certain simple diseases. You will get to know these from the fish dealer or from books as and when the need arises.

Having brought you this far in setting up your own aquarium, let me leave. Now it's between you and the aquarium. It's like arranging a marriage. Tell me how you fare when you find time.

Robert Grubh

ROBERT B GRUBH

Dr Grubh is the executive investigator of a Bombay Natural History Society project, "An ecological study of bird hazards at Indian aerodromes," of which Dr Salim Ali is the principal investigator.

A gear pair

DID YOU ever take a clock apart to see what made it tick? If you did, you probably came out with some parts left over when you got it back together again. And they probably included a few gear wheels. Gears are used in many machines. Frequently the gears are hidden from view in a protective case filled with grease or oil, and you may not see them.

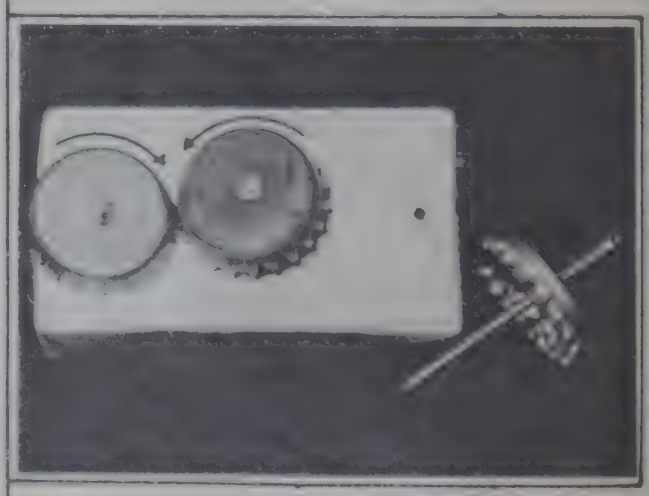
An egg beater gives you a simple demonstration of the three things that gears do. They can change the direction of motion; increase or decrease the speed of the applied motion; and magnify or reduce the force which you apply. Gears also give you a positive drive. There can be (and there usually is) a creep or slip in a belt drive. But gear teeth are always in mesh, and they allow no creep or slip.

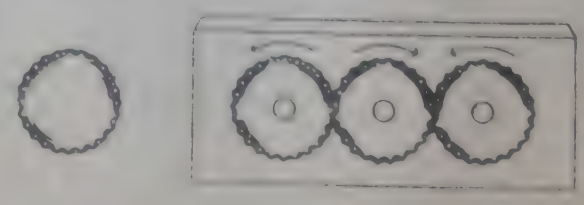
Changing speed

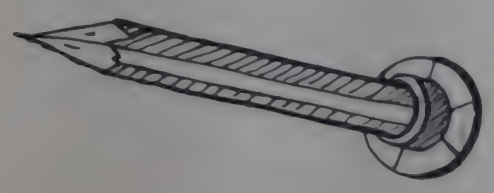
Follow the directional changes in figure 1. The crank handle is turned in the direction indicated by the arrow clockwise, when viewed from the right. The 32 teeth on the large vertical wheel A mesh with the eight teeth on the right hand horizontal wheel B, which rotates as indicated by the arrow. Notice that as B turns in a clockwise direction, its teeth mesh with those of wheel C and cause wheel C to revolve in the opposite direction The rotation of the crank handle has been transmitted by gears to the beater blades, which also rotate.

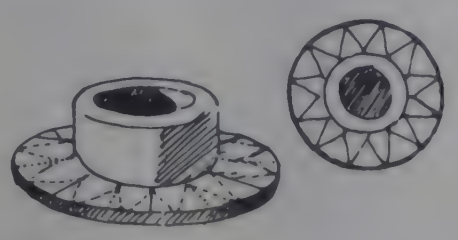
Now figure out how the gears change the speed of motion. There are 32 teeth on gear A and eight teeth on gear B. But the gears mesh, so that one complete revolution of A results in four complete

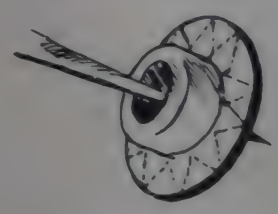
Vasant Vedre

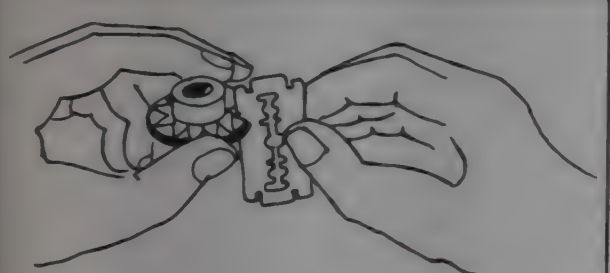


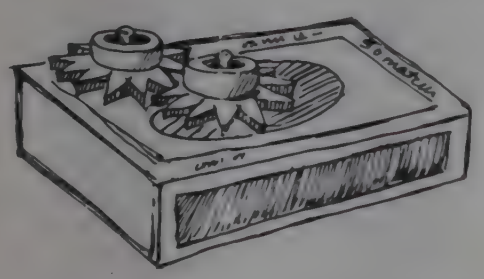


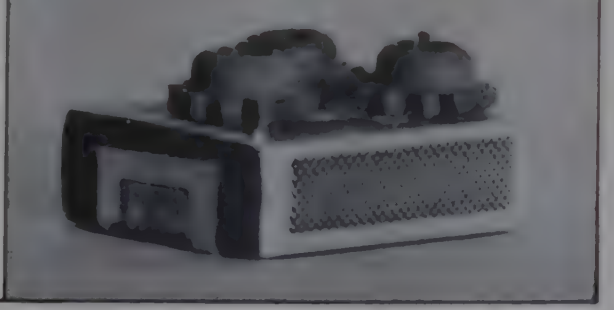












revolutions of gear B. And since gears B and C have the same number of teeth, one revolution of B results in one revolution of C. Thus the blades revolve four times as fast as the crank handle.

There is always a trade-off between the speed and the force. You can increase speed at the expense of force. The same thing happens with the egg beater. The magnitude of the force is changed. The force required to turn the handle is more than the force required to whip the egg yolk by the blades. Therefore a mechanical advantage of less than one results.

Another example of changing speed, using gears, is found in your clock or watch. The mainspring slowly unwinds and causes the hour hand to make one revolution in 12 hours. Through a series — or train — of gears, the minute hand makes one revolution each hour, while the second hand goes around once per minute.

Changing direction

When two external gears mesh, they rotate in opposite directions. Often you'll want to avoid this. Put a third gear, called an *idler*, between the driver and the driven gear. But don't let this extra gear confuse you on speeds. The idler does not change the gear-ratio at all. The idler merely makes the driver and its driven gear turn in the same direction.

Magnifying force with gears

Gear trains are often used to increase the mechanical advantage. In fact, wherever there's a reduction of speed, the effect of the effort you apply is multiplied. The simple, hand-operated, cane-juice crusher illustrates this best. Here a pinion — a small gear with 12 teeth — rotates a large bullgear with 72 teeth. Thus one complete rotation of the crank arm by a man turns the crusher rolls by only one-sixth of a revolution. But in the process the force applied is multiplied many times over.

Bottle cap gears

Simple gears can be made using soda water bottle caps. With a hammer and a medium-sized nail make holes exactly in the centres of several such metal caps. Place two caps on a block of wood, so that their tooth-like projections mesh together. Fasten them down with shoe-tack nails but make sure that they still turn easily. Turn one of the caps and note the direction in which the other turns. Add a third cap and note the direction in which each cap turns (see Fig 2).

Injection bottle cap rubber gears

Flexible and non-breakable gears can be made using old-injection bottle rubber caps (see Fig 3). Take a hexagonal pencil and place it in the trough of the injection bottle cap. Using the hexagonal pencil as a template, mark out six equidistant points on the rim of the cap. Put mid-points in between these six markings, such that the rim of the cap is now divided into 12 equidistant sectors. Now, mark out 12 regular V-shaped teeth on the rim of the cap with a ballpen. Make a hole in the centre of the rubber cap using a babool thorn or a divider. Insert a small piece of ballpen refill in this hole. The ballpen refill acts like a bush or a bearing. Using a new blade, cut out the 12 teeth on the rim of the rubber cap. Make several such gears. You can mount these gears on a matchbox top with the help of paper-pin axles. Make a gear train with several such gears in mesh.

You must have noticed that a single gear by itself is a great loner. To be at all effective it needs a mate — or another gear to mesh with. With the injection bottle rubber gears you can change the direction of rotation, and also transmit a drive. But because all the gears are the same size and have the same number of teeth, you can't do anything to change the applied speed or force. You'll have to rack your brains to find a way to do that.

ARVIND GUPTA

Mr Gupta, an electrical engineer, has been involved with People's Science Movements. At present he is on a Department of Science and Technology fellowship writing a book on matchstick meccano and other science experiments.

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Speech delivered by Dr. A.S. Ganguly, Chairman, Hindustan Lever Limited at the Annual General Meeting held in Bombay on Thursday, 29th May, 1986.

We are all captives of the picture in our head --- our belief that the world we experience is the world that really exists.

—Walter Lippmann

The rapid changes which have taken place in the country, particularly during the last few years, owe their origins to the historic decisions concerning India's economic development formulated since Independence. The debate on how things could have been done better or differently, as also the virtues and drawbacks of what is being planned for the future, will continue. Nevertheless, it is necessary for us to try and comprehend some of the fundamental changes which have taken place in the country's economy as well as some of the broad issues concerning the future.

Business and industry is part of the nation's economic fabric. Hindustan Lever Limited, for instance, like many in the private sector, has during these years grown, diversified and is regarded as a profitable and professionally managed company by its employees, shareholders, business associates, consumers and the general public.

The Company, like the country, is a product of a process of planning and change. Since the measure of planning is not intention but achievement, it is useful to take stock from time to time, draw appropriate lessons and be more pragmatic about the future. This year's Annual General Meeting speech, therefore, concerns itself with a survey of certain changes, both nationally as well as within the Company.

In the first section, I have briefly reviewed some of the achievements in the Indian economy and how these have led to impressive gains. This is not a comprehensive economic review but only a limited, qualitative survey for the purpose of a general discussion. The second section consists of certain features of growth, diversification and change in Hindustan Lever as well as their short and medium term consequences. The final section concerns some future perspectives.

The Indian Development

Several hundred treatises have been written and will continue to be published by eminent Indian and foreign economists about India's economic policies, progress or the lack thereof. The developments in India and China are of important consequence to the vast majority in the developing world who are generally resource-constrained, as well as increasingly interdependent in the world economic order. What does this mean to those who conduct business? They should at least be able to appreciate the basic elements of the process of change in these countries in order to be in harmony with an increasingly enabling environment and be able to evaluate business and investment decisions objectively to participate in an exciting era of growth opportunities. However, in this speech, I have limited the discussion to India alone, since information concerning China continues to be elusive.

India's progress in development leading up to the present time can be roughly divided into four broad periods. The most important and underlying factor has been the successive Five Year Plans which defined the objectives, targets and aspirations of the people throughout this period.

The first period starting immediately after Independence and until the late fifties laid the foundations for the current state of our economy. In 1947, India, with her vast and growing population and low per capita consumption and income, poor agricultural productivity and a rudimentary industrial base, defined her developmental priorities based on self-reliance, distributive social justice, individual freedom and a democratic polity. These must be viewed against the background of the aspirations of a newly independent nation at a time when the industrial world was trying to recover from the aftermath of World War II and funds and resources were major constraints.

The second period beginning in the sixties was probably the most difficult decade of our brief post-Independence history. In one sense, it was the beginning of a turning point. The shortage of food was acute, requiring massive imports. These and the imports of strategic defence needs and the devaluation of the Rupee in 1966 put an unprecedented burden on our fledgeling economy. But it was also in the same decade that India demonstrated the resolve to overcome these massive impediments. The revamping of her agriculture, now popularly called the "green revolution", created a base for food self-sufficiency and a major drive for import substitution helped to stem the tide of imports. The "green revolution" was itself helped by the widespread adaptation of genetically bred seeds, increased fertiliser inputs, a suitable pricing policy and dispersal of the cash economy from its predominantly urban concentration to the farming sector. This was also the beginning of long term irrigation and water management programmes which in subsequent years have paid handsome dividends.

During this period, Indian industry faced severe difficulties and constraints. While the public sector was coming into its own, even though at a considerably high cost, private industry had to contend with severe price controls, poor investment opportunities and profitability, and restrictions imposed by the Monopolies Act in an already closely controlled and monitored environment. Import restrictions and import substitution provided some opportunities, but, in retrospect, one must admit that scant advantage was taken of even the limited opportunities in spite of the industrial obsolescence and an environment of shortages.

The decade of the seventies can be considered, in retrospect, a decade of consolidation and preparation for change. The determined response to the oil shock of 1973, the enormous and successful investment in oil and natural gas exploration, the competent management of the periods of drought were, by any measure, spectacular efforts. While inflation raged in many parts of the world, throughout this decade the Indian economy experienced single digit inflation for much of the time and the generation of Indians raised on prudent consumption habits managed their increased earnings by saving at the rate of 22-24%. At the same time, India, very prudently, avoided excessive external indebtedness, at considerable cost to some of the development projects. Industrial and agricultural production increased significantly and in an uninterrupted manner. This gave confidence to the administration to progressively withdraw the debilitating price controls which had shackled and severely hampered industrial development and growth.

The second oil shock of 1979, although painful, had also to be managed within India's self-contained but now forward moving economy. The negative aspects, in spite of all these developments in our country, were that close to half the population was still below the "poverty line" and the tight administrative controls on industrial development and growth continued to be a major burden on our already high cost economy. Increased obsolescence prevented productivity improvement. These two issues continue to plague our economy even today and, along with the all-pervading decline in work ethos in organised industry, they are likely to become a

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major drag on India's development plans and programmes to eliminate poverty.

It was also during the seventies that the growth of the "unaccounted sector" of the economy accelerated, building up a large black economy variously estimated to be accounting for between 26% to 40% of the GNP. All these portents may have reinforced the realisation that the economy had gained strength as well as a propensity which, if managed pragmatically, with determination, could be more effectively utilised to tackle the problem of poverty, increase industrial production and employment, and at the same time curb the alarming growth of the black economy and pockets of conspicuous consumption. Just as making cash credit available to the farming community was key to the "green revolution" in the sixties, it was probably realised that unshackling the productive forces in the economy could be the key to more rapid economic development and attainment of social justice during the closing decades of the twentieth century.

This realisation began to find expression in the form of policy starting in 1980. To begin with, the policy changes concerned boosting production and productivity. However, in 1985, one witnessed the beginning of the convergence of long term and pragmatic fiscal and industrial policies for the first time. The policies are meant to permit Indian industry to modernise, achieve economies of scale and reduce costs, all leading up to an accelerated rate of growth. It intends to reward savings and returns from investments while taxing conspicuous consumption and unproductive expenditure. While attempting to contain administrative expenditure, the policy will hopefully permit more effective implementation of programmes for alleviating poverty. The long term exim policy is expected to lower costs, stimulate competition and, in general, increase the interplay with global trade opportunities.

All this represents a shift from a tightly controlled, low growth supply side policy to a more demand based and competitive era. It is a bold experiment in preparation for a better economic future for all sections in our society. The argument that India has done well as a low income, low consumption country through self-reliance cannot be sustained perpetually. Unless the economic forces which have been developed and patiently nurtured during the last 38 years are now gradually unleashed, it will not be possible to harness the critical mass of the Indian economy for tackling the problem of poverty, raising living standards and providing employment and entrepreneurial opportunities to the highly competent and capable younger generations who are entering the mainstream.

It is not the contention that economic pragmatism is the final answer to all the issues that we face. The problems of endemic unemployment, hyper-urbanisation, landless labourers and large pockets of low agricultural productivity remain. With increasing competition, the incidence of industrial sickness is also increasing. Problems of health, education, urban housing and population growth are mind boggling. Similarly, unrealistically disproportionate ambitions and a static or decreasing productivity work ethic amongst the fortunate minority who are employed in organised industry are major impediments in the economy.

In order to reverse the high cost of the economy, to sensibly utilise the high buffer stocks of food and to solve an increasingly difficult balance of trade, we need some major structural shifts which are yet to materialise. In spite of the enormous problems that lie ahead, the overall picture is one of buoyancy and forward thrust. While debates will go on, it would be erroneous to ascribe the achievements of the past to any particular ideology and the current programmes to the effect of market forces. The developments of 38 years are typically Indian : a nation which continues to be poor by other standards is trying to build a brighter future and better quality of life for her people. It is confident of achieving these goals because of the inherent ability of the people, their sense of social justice and their successes in self-reliance.

The Indian development profile will be eventually recognised as a model having wider relevance. India's economic propensity now makes it imperative not to leave business to elements of social change alone, but make it a product of strategic planning so that it is possible to predict and utilise the outcome with more confidence during the next ten years than it may have been possible a decade ago.

Developments In Hindustan Lever

Change is seldom apparent immediately. It would be wrong to try to correlate change quantitatively in order to comprehend its impact. Although qualitative, the effects of planned change are substantive as they cover a longer time span and leave their indelible mark on societies, organisations and individuals. Shorter term changes are generally reactive responses to immediate environmental stimuli as contrasted with proactive and planned change. In this section on Hindustan Lever, we are not concerned with short range reactive changes, but with broad trends and signals of long term developments.

Hindustan Lever, as it is today, is a product of managing change over several decades. Management of change is a tradition in the Company which is reinforced and refined by successive generations of managers. Whereas there are several examples of change spread over the years, in order to illustrate the point, it may be sufficient to describe only a few significant events. Some of these have been referred to in earlier speeches but do bear repeating in order to place them in the historical perspective as seen in 1986. The purpose is to refocus on, and reinforce for the future, those qualities which have permitted Hindustan Lever to grow, diversify and become a significant part of the Indian private sector.

1. Management

The growth and development of what we now recognise as modern Indian professional management in Hindustan Lever is the result of a long term plan for managing the Indian business. The progression of this plan eventually led to the appointment of the first Indian Chairman, Mr. Prakash Tandon, in 1961, to be succeeded in later years by Mr. Vasant Rajadhyaksha followed by Mr. T. Thomas. Much of the Company's managerial strengths today are a consequence of the developments which flowed out of this perspective programme. The programme has progressively matured to a point when Indian managers are valued internationally, with Mr. Thomas joining the Unilever Board in 1979 and several managers occupying senior, including Board, positions in a number of Unilever companies outside India.

Within Hindustan Lever, the process of change continues to keep pace with the rapidly evolving industrial and social environment. Training and development have played a critical role in preparing all sections of employees and helped foster a climate for improved productivity and meaningful human relations. While many modern management tools from the West as well as Japan have obviously been useful, it is now increasingly recognised that our own social values have a predominant influence in order to successfully manage an industrial enterprise in India.

It is this interweaving of social values along with appropriate management practices which will become more crucial for successful future development. Successful management ultimately combines a concern for those who are employed in the Company, the shareholders, the consumers as well as society at large.

2. Research & Development

Another landmark event in the process of change was the decision to invest in scientific research and development in India by Hindustan Lever in 1958. At a time when the country's balance of trade was very adverse and raw material shortages and other growth constraints were developing, the establishment of a modern Research & Development Centre was an act of wisdom and foresight. In retrospect, much of Hindustan Lever's market leadership in consumer products, its diversification into chemicals, agribusiness and exports and a deep-rooted, Company-wide, innovative work ethic can be traced back to the confidence generated by the Research & De-

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velopment set-up over the years.

In addition to the recognised eminence of the work of Hindustan Lever's research scientists in India and abroad as well as an impressive number of patents and publications from the Research Centre, it may be useful to recall a few specific examples of achievements in the industrial sphere. The successful Research & Development undertaken on minor and unconventional oils in the sixties virtually ended the dependence of the soap industry on imported raw materials and indigenous edible oils. The use of minor and unconventional oils has generated a major local industry and is a prime example of the impact of import substitution. People tend to forget that some simple end products are the result of some very complex innovation and scientific research. This work is a classic example of one such case.

Organic synthesis of fine chemicals and fundamental work on catalysts led to the rapid development of Hindustan Lever's chemical business which has grown further with the investment in STPP and DAP fertiliser in later years. Similarly, the significant discoveries in plant physiology, photosynthesis and bacterial genetics laid the foundation of an agribusiness which has exciting growth potential. The understanding of the endocrinology of prawns has helped us to enhance aquaculture and this is the basis of a new fish farming opportunity. The first commercial chromatographic fractionation technology has permitted significant value addition to sal fat exports. There are several other examples but these are illustrative. The Research Laboratory's work is of international standard, as indeed all research work ought to be, and is today an important constituent of Unilever Research along with two research establishments in the U.K., and one each in Holland and the U.S.A.

Scientific discoveries and innovation today are an integral part of Hindustan Lever's strategic plans for the future. The single most valuable lesson of undertaking frontier area scientific research in our Company was the learning process of transfer of technology. It is now clear, following more than twenty years of experience, that the ability to transform discovery into a commercially viable end product or new knowledge, with frequent iterations of what works in the laboratory with what is required in the marketplace, is the single most important difference between viable and non-productive research. The Research & Development effort, being an integral part of the main business in Hindustan Lever, was, I believe, imperative for whatever success we have achieved in this respect. It provided a workable framework for accountability without unduly interfering with the pursuit of science. The other was the ability of the business to be patient with what is invariably a slow process of converting discovery into technology.

Research is both essential and valuable; hence the ability to harness scientific research for economic development is a highly complex exercise which is being debated anew. Policy issues dealing with import of technology and product development, as distinct from basic scientific research, have been discussed earlier and constitute important elements in this debate.

Scientific research in Indian industry is still rudimentary. From time to time, it is naively suggested that economic development can be sustained by Indian industry without substantial and meaningful investment in scientific research. Delay in investment in scientific research means delay in investing in the future and a sure prescription for obsolescence.

3. Investing for Change

(a) Chemical: The decision to substantially expand the chemical business and broad-base the Company's successful consumer product groups was based on assessment of long term opportunities in the sixties as well as the strategy to strengthen the core of the Company. In addition to modernising the existing organic chemicals and catalyst investments, a major investment in inorganic chemicals was made and came on stream in Haldia in 1979. The technology for manufacturing phosphoric acid, sulphuric acid and STPP led to investment in and commissioning of the Diammonium Phosphate fertiliser plant in 1985 and reaffirms the strategy of the perspective plan. The goal of broadening the Company's base has been substantially achieved and the chemicals business is today firmly established in the growth mode side by side with the Company's soaps and detergents business. It also gives us confidence to consider investments in new areas ranging from sophisticated catalysts to a variety of natural and synthetic complex polymers. These are products based on frontier areas of scientific research in material science and low energy technology.

(b) Energy: The steep rise in energy cost once and for all changed the nature of manufacturing technology the world over. Industry's only choice was to bring down energy needs in the short term and modernise its technology in order to remain competitive.

Following the 1973 oil shock, a short term as well as a perspective plan was drawn up for energy conservation in Hindustan Lever. As a result of a Company-wide drive, within a short span of two years the energy consumption per unit 'output' was reduced between 8-12% in the different manufacturing units. The long term plan included investment in modernisation of many high energy consuming plants and processes, converting batch and semi-continuous processes to continuous ones, as well as changing over from diesel power generation to modern and cost effective cogeneration units. By systematically implementing these plans, considerable savings have been achieved in energy and costs while at the same time extensively modernising the manufacturing base of the Company.

(c) Environment: Hyper-urbanisation and environmental pressures are major issues requiring a perspective plan for dispersal of industries, which in the short term not only meets statutory requirements in existing locations but also takes major initiative in safety, pollution and disaster management.

There has been for some time a Government policy to encourage dispersal of investment to the unindustrialised parts of the country as a major economic and social goal. The Company has been responsive to this for several years. The first response was the investments in Taloja in Maharashtra and in Jammu & Kashmir in 1976, followed by Haldia in 1979 and more recently in other backward areas of Madhya Pradesh, Maharashtra and Uttar Pradesh.

It is the interweaving of investments in new plants, modernising and decongesting older units, along with specific actions to reduce hazards and protect the consumers and the environment, which constitute the basic programme also for the future.

Two legislations which have profoundly influenced the performance of the Company are the *Monopolies & Restrictive Trade Practices Act*(MRTP) and the *Foreign Exchange Regulation Act* (FERA). The restrictions to the growth of the Company's traditional business, at a time when burdens of price controls were overwhelming, were indeed debilitating. However, the Company's decision to broaden its manufacturing base, its impressive record of import substitution through the application of sophisticated technology derived from its own R&D and its remarkable export performance were important factors in successfully meeting the requirements of FERA.

It may also not be as widely known that Hindustan Lever was probably the first foreign subsidiary to offer equity to Indian shareholders in 1956, much before the FERA enactment had made this mandatory. Beginning with modest numbers, the Company today has over 100,000 Indian shareholders who also include a majority of the employees.

Similarly, the Company has an equally long history of achievements in exports. The Export Division was already well established in the sixties. Import Substitution and exports were all along considered to be opportunities and were an integral part of the Company's long term strategy. The achievements of the last five years have been particularly impressive. The Company today is the second largest exporter in the private sector having exported over Rs.335 crores worth of products in the past five years alone. In addition the value of import substitution arising out of in-house R&D and other innovative efforts is worth several crores per annum.

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The reorganisation of the edible fats, dairy and animal feeds businesses with Lipton India Limited was the outcome of the strategy to concentrate on core and high technology investments in Hindustan Lever, as well as to create a synergy for the future. This was an exercise which has served to avoid obsolescence and sickness in a part of the business which was hamstrung by controls on growth, and also helped protect the interest of employees, shareholders and consumers.

Over the years, financial management, both in the ongoing business operations as well as in new investments of Hindustan Lever, has undergone a metamorphosis to reflect the fast changing needs of money management. These include inflation accounting, understanding and articulating the needs of investors who provide capital for the operations of the business, and long term forecasting of cash flow, working capital and assets utilisation.

In India, the urgency of industrial development spurred enormous capital investment supported by fiscal benefits which acted as catalysts. Even today, only investments of the order of Rs. 500-1000 crores in projects are considered truly impressive. While there is no denying that heavy investments are essential for our development needs, the importance of capital utilisation is virtually ignored in corporate performance assessment. Capital utilisation is considered as important as new investment in Hindustan Lever. Given our resource constraints and the high cost of our economy, hopefully, this will be recognised more widely across the industrial sector in which enormous investments have been made during the last 40 years. Some of the problems associated with obsolescence, lack of modernisation and industrial sickness can be traced back to the fact that some major investments have remained grossly underutilised. Improvement in capital output ratio in investments already made must be considered as important as new capital investment. It is likely that this will, in its train, highlight the need for investment in R&D by industry and the introduction of cost-effectiveness programmes as an integral part of the working plan for India's future industrial development.

4. Marketing

Effective marketing is the most important activity in any business. In Hindustan Lever, over the years, marketing, distribution and sales have been modernised through innovations. Made more cost-effective, it will continue to be very important in the process of change. It is now more widely recognised that marketing and advertising are not the exclusive preserve of an urban, and what is considered to be an alien, lifestyle. It is not sufficient to make new discoveries and invest in new technologies. If we do not have the ability to package and deliver goods and ideas to the end user in a manner in which they fulfil real needs cost-effectively, sustained economic development cannot take place.

Whether it is selling consumer products to the housewife or hybrid seeds to the farmer, marketing and communication are beginning to be recognised in India as being indispensable vehicles of economic progress. In a high cost and shortage economy, this may not have been as widely perceived in the past, but, with our rapidly growing industrial and agricultural economy, the importance of marketing is self-evident. As a matter of fact, I believe, in the case of many of the societal problems such as health, education, population control, eradication of poverty and so on, modern marketing and communication will play a role far greater than has been appreciated as yet.

The marketing strength makes it possible for Hindustan Lever to distribute its consumer products, chemicals and agriproducts to the remotest parts of the country, while at the same time providing us a window to the various facets of our rapidly changing economy, and to anticipate opportunities. I also believe that these are the same strengths which will be crucial for the growth of our exports and must be so perceived by those engaged in the strategic planning for exports from India.

5. Agribusiness

The more recent investments in agribusiness by the Company is an important example of management of change. India's spectacular achievements in agriculture are well known. Productivity potential makes the future possibilities even more exciting. This is especially so with the rapid progress in hybrid plant research, plant biotechnology, ecology and water management. This adds a new dimension to the nature and scope of agribusiness opportunities in the country.

Hindustan Lever's interest in agriculture began in 1957 with growing of high yielding variety of peas in Uttar Pradesh, setting up a milk collection system and a modern dairy as well as a successful animal feeds business. The organisation of the collection, extraction and upgradation of minor and unconventional oils also had a high degree of agricultural involvement.

But the more recent discoveries in plant and animal biochemistry by our scientists is changing the nature of the whole business. These range from understanding the fate of dietary carbon in cattle and protecting dietary proteins in order to maximise milk yields, to some novel discoveries of sources as well as the mode of action of certain naturally occurring organic substances in assisting all plants to improve the efficiency of utilising solar energy and soil nutrients. To this can be added a whole host of opportunities in hybrid oilseeds and pulses, genetically modified nitrogen fixers and tissue culture propagation of species ranging from cardamoms to coconut. To enhance eco-compatability, there are other groups of compounds such as pheromones and bioinsecticides in different stages of development.

New knowledge and its application generate new issues. These range from marketing and communication (how does one convey to the farmer the concept of photosynthesis?) and years of extensive field trials to generate data and obtain necessary Government permission, to training sales and field personnel as well as developing trade and distribution channels. Modern agribusiness, particularly one based on biotechnology, by its very nature is a delicate interplay of scientific input and commercial exploitation. The learning curve is long and arduous. This is an investment in the future and signifies exciting possibilities.

Some Future Issues

The descriptions in the previous sections may help us appreciate how a people and their environment shape the future of nations and organisations. As a nation, we started with poor resources and economic restrictions. Innovation and import substitution provided certain opportunities, but restrictions and controls bred inefficiencies, high costs and shortages. All through this period, the principles of professionalism were preserved by the Company, as also its strength in marketing and a nationwide sales and distribution network. The character of our business has undergone a gradual change with expansion in chemicals, reorganisation of foods and animal feeds and entry into agribusiness. The strength in scientific research has acted as a cementing force. We have continued to recruit and train an increasingly competent and productivity minded workforce, and managers who have thrived in an innovative and professional environment. There is a heightened sense of social awareness reinforced by training and participation in the Company's intensive integrated rural development programme.

But what about the future? The Indian economy has attained a critical mass. There is a pervasive feeling of confidence in the people's abilities and their sights about the nation's future. Poverty alleviation, a core issue, now seems closer to solution as also illiteracy and communicable diseases. Ecological dysgeny and the burgeoning population problems, however, appear to be more formidable. But in spite of this there is an ambience of buoyancy, a confidence built upon an edifice of self-reliance, high national savings and an awareness of the need for social justice.

The manufacturing industry which has survived under protection and restrictions is now being urged to grow, and encouraged to modernise, generate more employment, spread to backward regions and reduce cost. In a country where resources are limited and where pressures of diverse demands increase, management of opportunities is acquiring a wholly new dimension.

Continued

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MANAGING CHANGE

Under these circumstances, the responsibility of the agents of change, such as managers, is heightened manifold. This includes more public and lateral accountability, social responsibility, environmental concern, and judicious investment in scientific research. Much will depend upon how we modernise our training and development programme for all sections of our employees to meet the needs of the future. The young worker and manager of today have a far greater burden both in the Company and in society, for his actions as well as the contributions he will need to make. In some issues, the effects of one's actions are more dependent upon one's competence and commitment to inner imperatives rather than external controls. In place of its traditional adversariness of stance with Government, business may soon find a new and unaccustomed role: of moving shoulder to shoulder to convert opportunities into economic realities for a better future. If this has to be brought about and fostered, both training and change of approach must reach far beyond and not just be confined to those engaged in Government or in industry. It must be integrated with education and training in schools, colleges and vocational institutes for creating effective managers, scientists and administrators of the future.

In Hindustan Lever, we believe that the Indian manager is unique in seeking opportunities and succeeding in accomplishing difficult goals, notwithstanding the vicissitudes and vagaries of the environment. He has generated flexible skills to match unforeseeable problems. Further, this quality has been nurtured in an environment of uncompromising professionalism. The confidence in planning for the future springs from a demanding environment and a belief that the country's economic propensity will provide the forward thrust needed for a host of activities: to raise the standard and quality of life of a generation which has more young people than ever before; to purposefully tackle the problems of poverty; and to take part aggressively in international trade and commerce as befits a country of our size and competence.

Management of change is the essence of life; both of conscious changes in technology, communication and way of life ushered in by advances in science, behavioural as well as attitudinal corollaries. With a vast amount of capability at his disposal through the advances in science and technology, and the power and ability to control his own destiny, it is still necessary for man to continue wooing Nature if he wants to ensure a better quality of life and sustained development and progress for future generations. The resources of the land have to be used judiciously and with care, so that we hand it down to our successors more enriched than what we inherited. This would require a more sensitive, perceptive and caring management of change by Government and industry alike in the years ahead. Such a management of change has to be guided not only by immediate causal forces, but also by certain distant, though predetermined goals.

In this tryst with the future, industry has a pivotal role. In Hindustan Lever, we feel confident and proud to be a part of this adventure. Managing and accomplishing change will be the biggest and most rewarding challenge in planning for the rest of this century and beyond.

Note: This does not purport to be a report of the proceedings of the Annual General Meeting.

The full text of this speech is available in booklet form. Anyone who wishes to have a copy may please write to: Communications Department, Hindustan Lever Ltd., P.O. Box 409, Bombay 400 001.

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Death on the road

What is a quicksand?

BASICALLY, a viscous fluid. All over the world, there are places near river banks, lakes and water holes where cattle and people drown in soft sandy ground. This drowning is attributed to quicksand. Studying these locations shows us that there is quicksand when the terrain near an area of water like a river or lake rises and the water table which is parallel to the ground attains a level higher than that of the river or lake. This water from the higher level flows towards the river or lake. This causes an upward flow of water through some strata of silt or sand. In some cases, the upward flow may be sufficient to lift the sand or silt particles. Due to this, the soil loses its strength and behaves like a viscous fluid. That is what is called quicksand. This condition may exist a number of feet below ground level. In India quicksand has been reported in places along the banks of river Godavari.

There is a widespread myth that animals and people get "sucked" into quicksand. In fact, that just isn't physically possible. Man can easily swim in fresh water which weighs 1 gram per cubic centimetre, and easily float in salt water which weighs about 1.02 to 1.03 gram per cc. The viscous fluid of quicksand weighs well over 1.3 g per cc and it is almost impossible for a person to avoid floating in it.

So why do people drown in it? One possible reason is panic. Though the person can float easily in the fluid he will be partially immersed. Due to the highly viscous nature of the fluid the panicking person will easily exhaust himself and may not be able to keep his head upright and collapse on his face, leading to suffocation and death. But a person in a proper state of mind can easily keep his head upright by slowly moving his limbs and moving towards firm ground.

Let's explain the phenomenon of quicksand, by using a model. Take a U tube and funnel as shown in Figure 1. Fill the funnel with fine sand. Start filling the U-tube with water. When the water reaches a certain level in the U-tube, the upward force due to water across plane X-X and the downward force due to weight of soil become equal. The sand particles just start getting lifted. A coin placed on the sand surface will sink into the sand. This condition when the total upward force due to the upward flow of water and the downward force due to the weight of soil become equal is called quicksand. The sand has lost all its intergranular strength. The head or gradient of water required to cause quicksand can easily be derived using this model. (see box)

Fig 1 Occurrence of quicksand near rivers and lakes

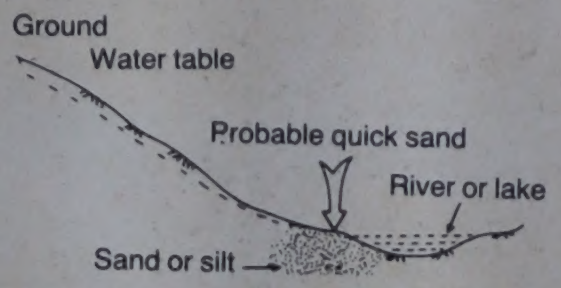


Fig 2 A model of a quicksand

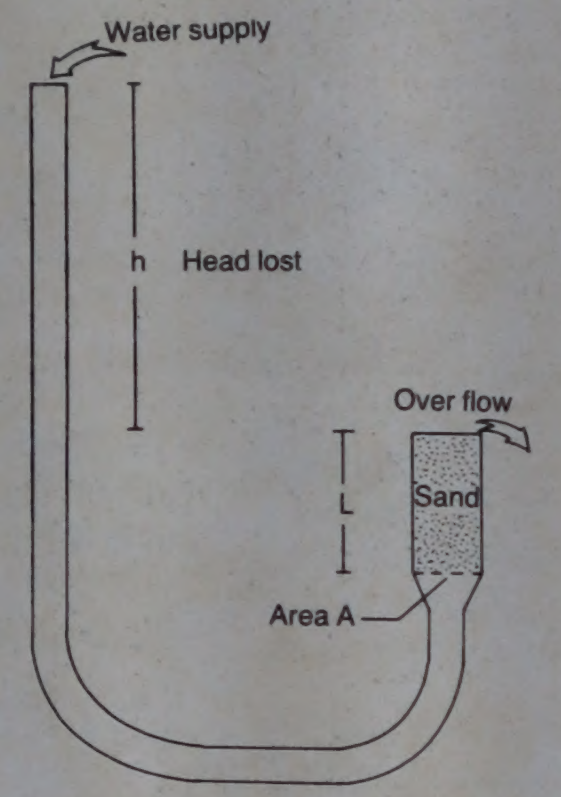
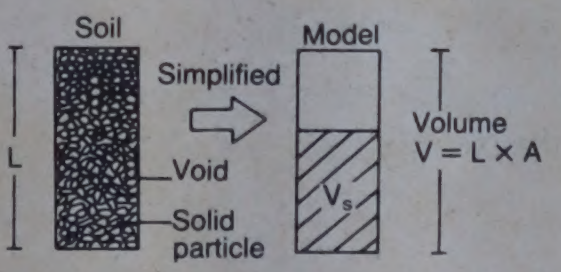


Fig 3 Calculation of volumes



$$e = \frac{V_v}{V_s} = \frac{V_v}{V - V_v}$$

$$e.v = (1+e)\,V_v \qquad V_v = \frac{e}{1+e}.V = \frac{e}{1+e}L.A.$$

$$V_s = V - V_v = \left(V - \frac{e}{1+e}.V\right) = \frac{1}{1+e}.V = \frac{1}{1+e}L.A.$$

The total upward force across X-X is given by $(h + L)\,Y_w A$

To evaluate weight of soil acting downward let volume of voids in the soil be V_v and volume of solids = V_s

The ratio $\frac{V_v}{V_s}$ is defined as void ratio = e

For the sake of clarity, using Figure 3, we get

$V_v = \frac{e}{1+e}$ L.A and $V_s = \frac{1}{1+e}$ L.A

So weight of solids = $G V_s Y_w) = G \frac{1}{1+e} Y_w$ L.A

Where G is the specific gravity of solids and Y_w, density of water. Weight of water in voids

$= V_v.Y_w = \frac{e}{1+e} Y_w$ L.A

Therefore, the total downward force across

X-X $= \frac{(G+e)}{1+e} Y_w$ L.A

For quicksand to occur

$(h+L)\,Y_w A = \frac{(G+e)}{1+e} Y_w$ L.A

Therefore, $\frac{h}{L} = \frac{G-1}{1+e}$

h/L is the gradient of water and in nature when it becomes equal to $\frac{G-1}{1+3}$, quick sand occurs.

Theoretically, quicksand can occur in a mass of big particles like pebbles too, but the large quantity of water required to maintain the gradient makes it practically unlikely. The reason why quicksand does not occur in clays under normal condition is due to the cohesion of clay, which is normally sufficient to overcome the upward forces. Also, cracks may appear in the clay allowing water to flow and release the stresses.

Quicksand conditions are an important consideration in Civil Engineering. During deep excavation in sand below the water table when water is being pumped out, the gradient may reach a critical value causing quicksand conditions. During the construction of dams, relief wells are provided to release pressures and avoid quicksand conditions in the downstream region. Quicksand conditions may also occur behind levees of rivers during floods.

DINESH R KATTI

Mr Katti is presently working for a PhD in Geotechnical Engineering at the Indian Institute of Technology, Bombay. He is co-author in several technical reports.

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